Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

NOVEMBER 1950

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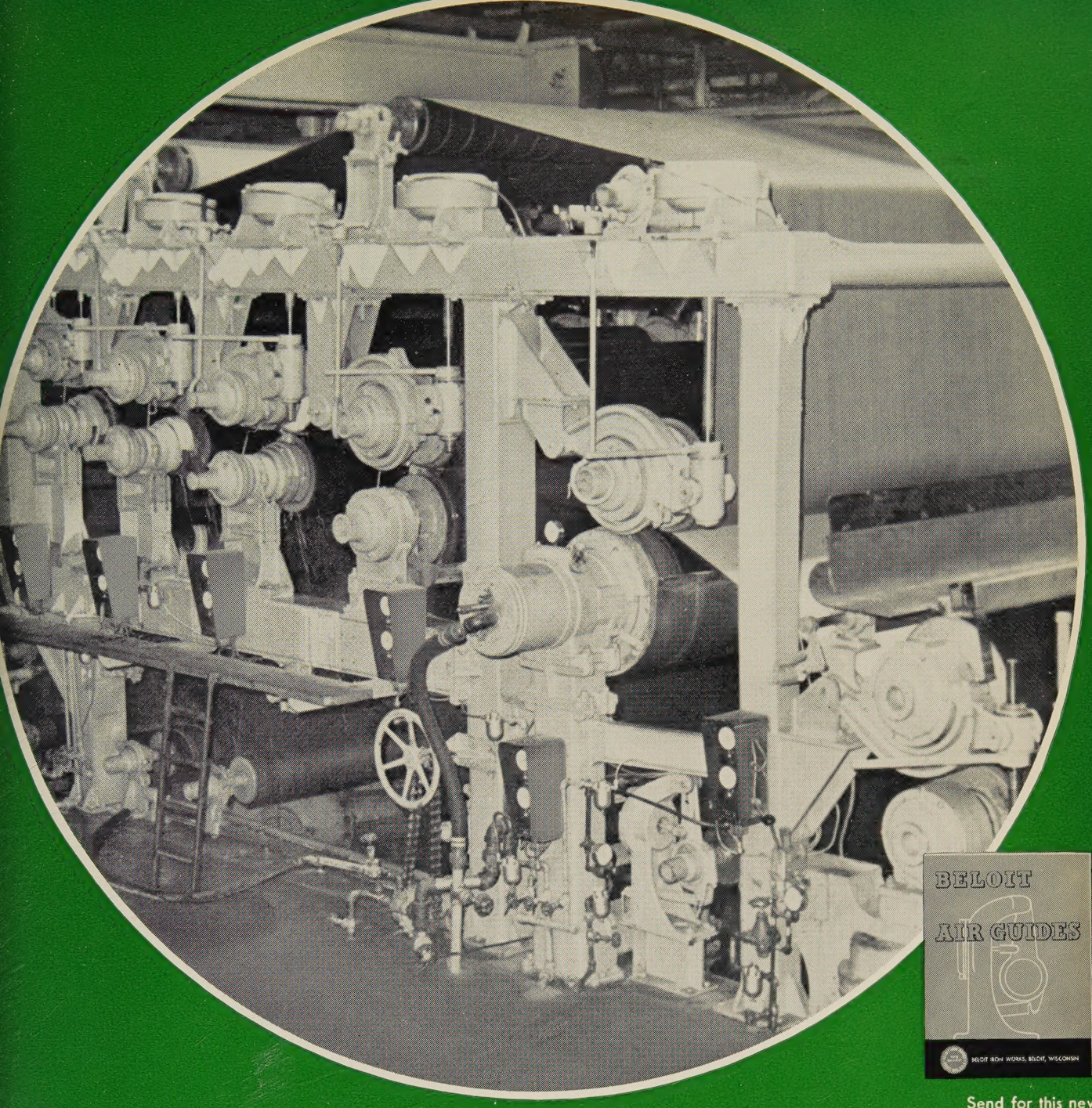

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Illustrated Story of Beloit
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Accurate sensitivity is assured with a Beloit Air Guide. The durable rubber diaphragm gives short, positive action—highly dependable under all kinds of conditions. Slightest variations are corrected, and drag is practically eliminated. Because of the simple, rugged construction, operator attention is reduced to a minimum. Beloit Air Diaphragm Guides are adaptable to modernization programs without the necessity of maintaining special spare rolls. Standardization of design makes possible immediate deliveries.—*Beloit Iron Works, Beloit, Wisconsin.*

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WHEN YOU BUY BELOIT . . . YOU BUY MORE THAN A MACHINE!

BELOIT

PAPER MACHINERY

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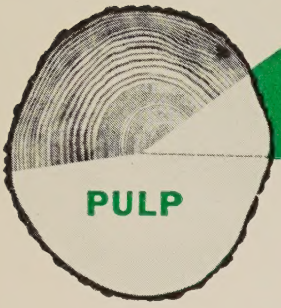

Don't be satisfied with methods that allow 20% of your potential product to be lost. With the revolutionary new Sutherland Systems you can convert this loss into profits. Commercial installations on a wide variety of pulps prove that you can save $6.00 per ton through higher yield and reduced consumption of steam and chemicals. In addition, you have clean, strong pulp suitable for high quality board and paper.

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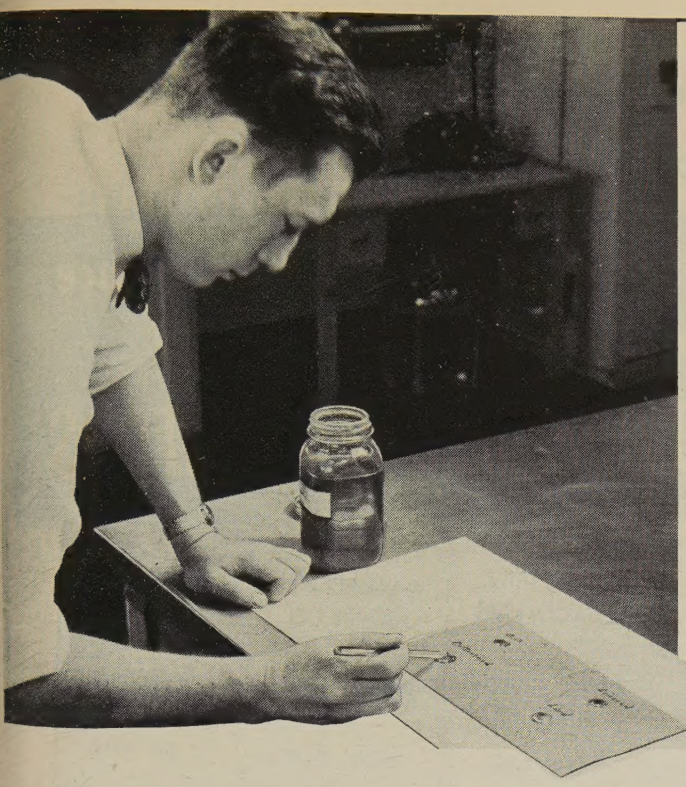

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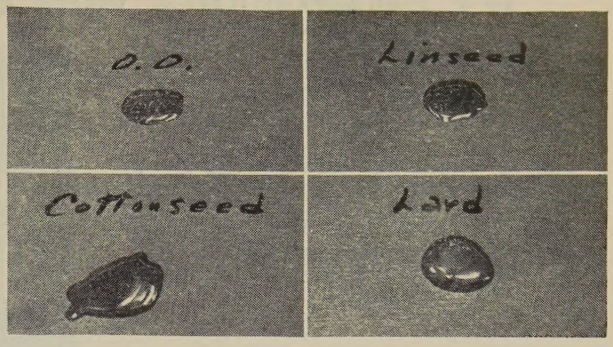

GREASE TEST—HOURS FOR PENETRATION

	Kraft	Chipboard
Olive Oil	120 +	120 +
Lard	120 +	120 +
Cotton Seed Oil	120 +	120 +
Linseed Oil	120 +	120 +

Best for coatings and impregnants—

Latices for Papermakers by Goodyear

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As *impregnants,* these latices will give tear-resistance, toughness, elongation, flexibility, excellent feel and drape, together with many other desired combinations of qualities.

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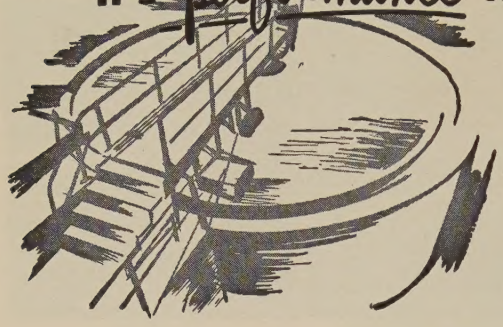

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OPERATION	SOFTENING	SOFTENING	SOFT. COLOR & TURB. REM.	COLOR REM.	ALGAE & COLOR REM.
NO. AND SIZE OF UNITS	2-35′ DIA.	1-31′ DIA.	1-45′ DIA.	2-80′ DIA.	1-50′ DIA.
CAP. PER UNIT, M.G.D.	1.5	1.0	3.1	10.0	3.0
GAL./SQ. FT./MIN.	1.08	.93	1.35	1.34	1.07
AVG. TURB. EFF., PPM	LESS THAN 0.2	5.0	2.4 to 4.7	3 to 5	4 to 7
SLUDGE—% SOLIDS	35 to 46.5	24.9 to 39.2	16.7	—	—

Here are the reasons for this performance...

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NOVEMBER 1950

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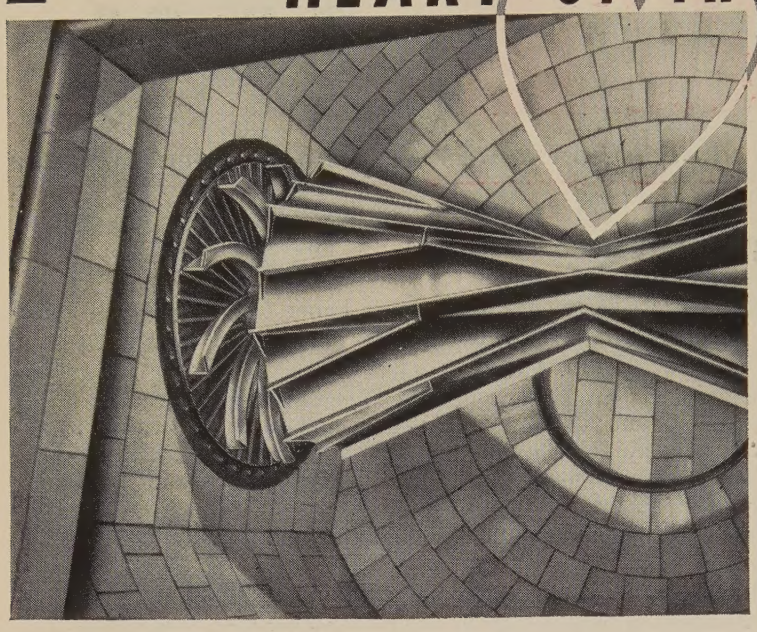
HEART of the E.D. Jones PULP-MASTER



Shown here — in a recent tile tank installation in a large midwest mill—is the rotor of the No. 4 size Jones PULP-MASTER.

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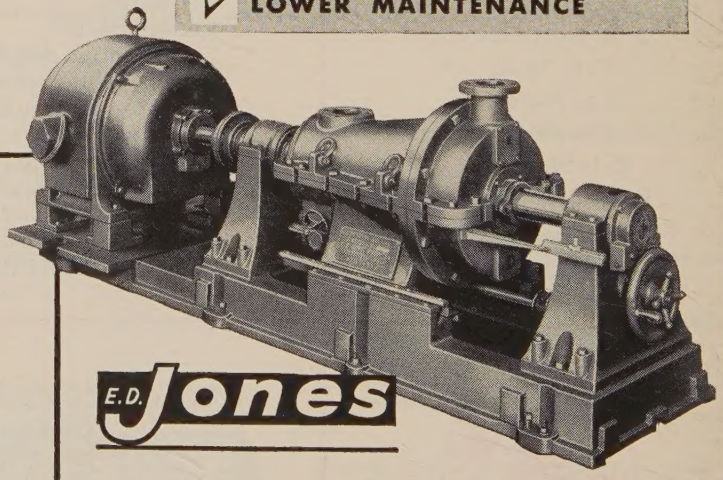

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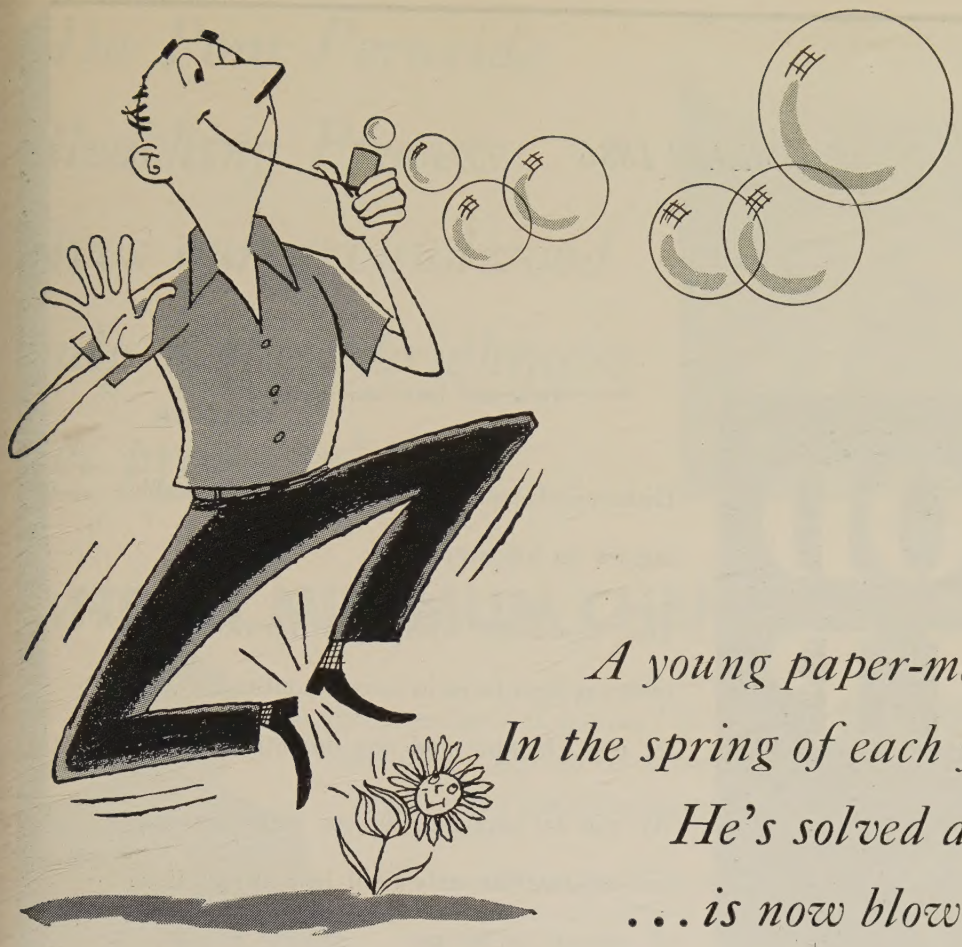

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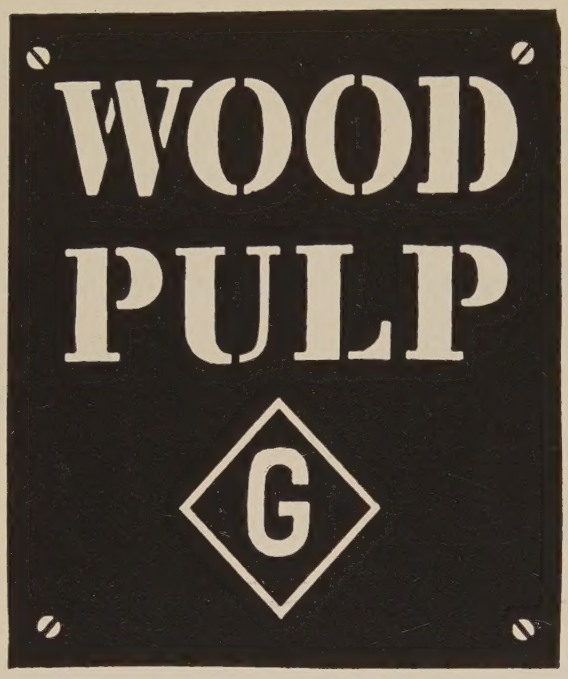

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St. George Pulp and Paper Co., Ltd. Mill at St. John, N. B.

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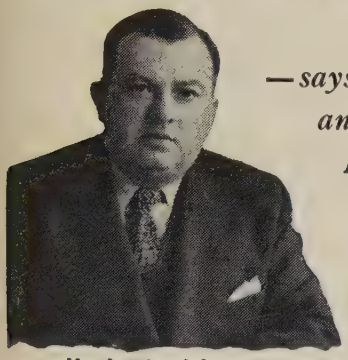

Mr. Antoine J. Lacroix,
V.P. and Gen'l Mgr.,
St. George Pulp and Paper Co., Ltd.

—says Antoine J. Lacroix, Vice Pres. and Gen'l Mgr. of St. George Pulp and Paper Company

Outstanding success in the peroxide bleaching of groundwood pulp is reported by the St. George Pulp and Paper Company, Ltd., of St. John, New Brunswick.

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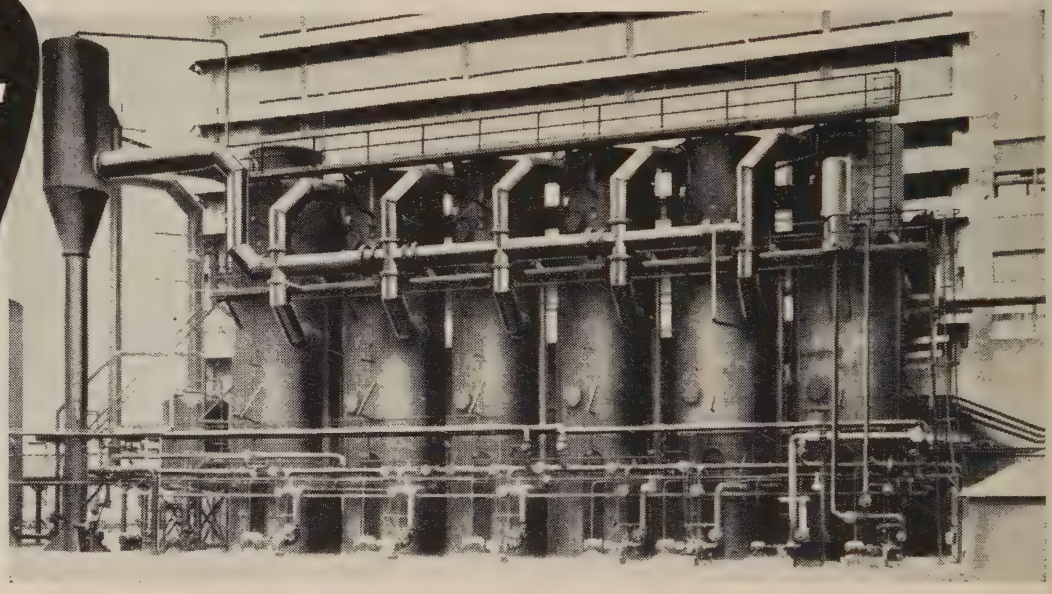

Conkey Integral Sextuple Effect Evaporator outdoor installation at southern pulp mill.

It's Self-Supporting—in more ways than one! Savings start the day the new Conkey Integral Evaporator comes into your plant. Unit is shipped fully assembled. A single up-ending operation sets it in place. As a result, you save on assembly, parts handling and erection costs. In addition, there are important savings in floor and building space—since no external centrifugal type separators, outside flash tanks and piping are needed. Where weather conditions permit, the entire unit may be installed outdoors—with no housing needed except for pumps and instruments.

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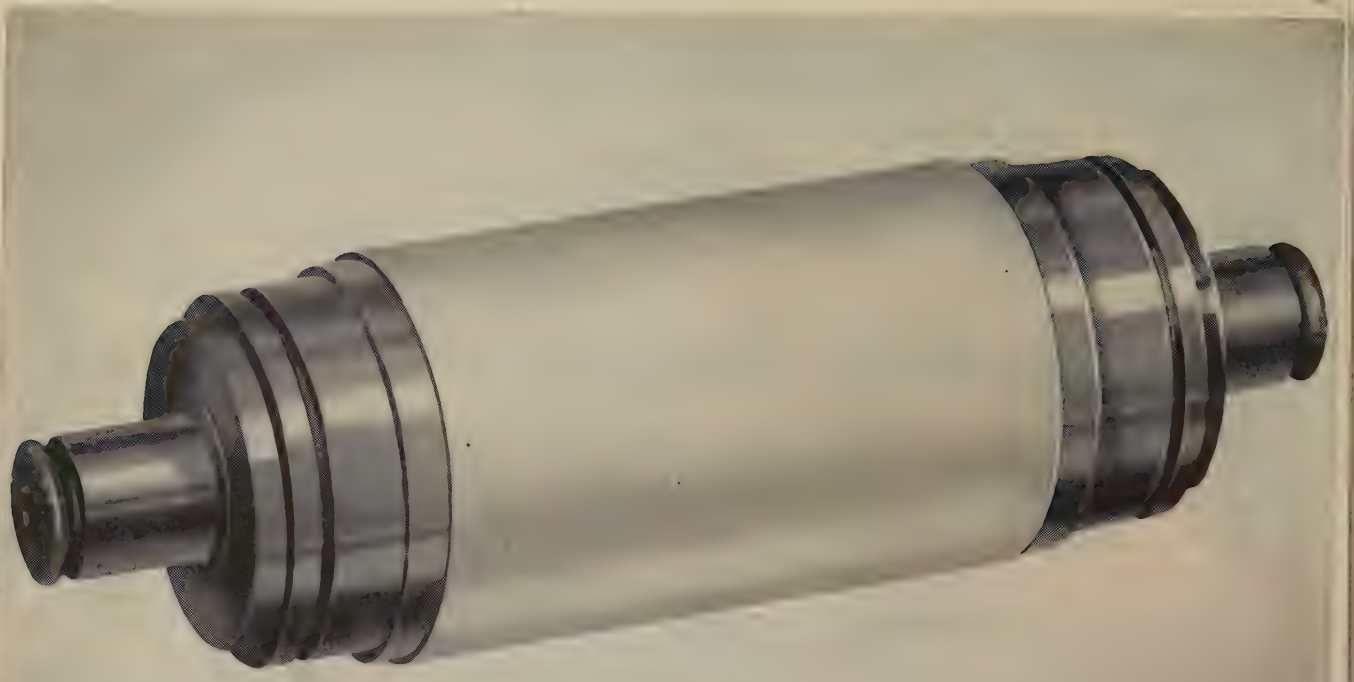

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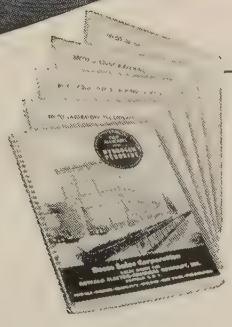
Upper nylon brush for spreading liquor



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Outstanding Material Handling Practices in the Pulp and Paper Industry on the West Coast

F. D. HELVERSEN

Today I am standing before you as a TAPPI member and not as a representative of the Crown Zellerbach Corp., and as a TAPPI member, it is my good fortune to present outstanding material handling practices in the pulp and paper industry on the West Coast; West Coast meaning at Weyerhaeuser Timber Co., Longview, Wash.; Longview Fibre Co., Longview, Wash.; Fibreboard Products Corp., Antioch, Calif.; Terminal Equipment Co., San Francisco, and the Crown Zellerbach Corp., San Francisco, Calif.

In preparing this paper it has been our idea to present actual outstanding practices in material handling without any theoretical considerations whatsoever. We are presenting no theoretical considerations because it is believed that you can read such considerations in a book or obtain the services of a man who can help in evaluating your particular problem. We feel that by presenting actual practices we make it possible for you to reuse any one of them as you deem practical. After all, ingenious reuse of already developed methods is the greatest part of progress.

Briefly, cases which apply to logging operations, wood handling at paper mills, chip handling at paper mills, pulp handling from machine to railroad car, newsprint handling from shipboard to storage or vice versa, paper roll handling for usage in making corrugated boxes, the handling of carton blanks in the stitching operation of a box factory, the material handling system in a converting plant, and the material handling system in a wholesale warehouse are cited. This presentation will conclude with one of the large-scale experiments in material handling that the Crown Zellerbach Corp. is engaged in at present.

Movable Spar

A conventional spar is built out of a tree. As you well know, spars are used in cable logging, and, as you can well appreciate, it takes a lot of labor to prepare a tree to make a spar out of it. Consequently, the Logging Department of the Crown Zellerbach Corp., together with Hyster Co. of Portland, has developed a movable spar. This spar was developed to cut down the cost of rigging as it costs approximately $200 to rig a spar.

The movable spar is 47 feet tall and has a total log hauling distance of 600 feet. It is equipped with two engines. One operates the main line, and the other is a small auxiliary engine which helps to tighten the guy lines. The main engine is a D-7 caterpillar engine of approximately 95 hp. The auxiliary engine is a Ford gasoline engine. The cost of the tower alone is approximately $10,000, including all cables and block guy lines, and the tractor is approximately another $10,000, making a total cost of $20,000 for the rig.

One of the principal considerations in developing this movable spar was that the Logging Department desired to utilize logs 20 inches in diameter and 48 feet long or smaller. The portability of the spar makes the logging of this size timber economically more attractive because of less cost.

Logging Truck Preloading Device

Figure 1 shows a portable boom on a spar and directly in front of it a preloading device for trucks and tractors used in hauling logs. Behind the preloading device in the foreground is the trailer which is supporting the far-distant half of the log already put on it. This log truck preloading device was developed by the Logging Division of the Crown Zellerbach Corp. and the Berger Engineering Works in Seattle, Wash.

The movable boom shown in Fig. 1, can be pulled off the ground and is free to rotate around the spar. The Logging Department of the Crown Zellerbach Corp. prefers to have every piece of equipment, even a boom, so that it can be moved on logging roads.

The preloader has two hydraulic cylinders which elevate the cross beam into the proper position, that is, the same elevation as the trailer behind it.

Then logs are loaded on the preloader and the trailer just as if the tractor were already in position. Once the logs are preloaded, the tractor, which was busy with another trailer and has returned, is switched to the trailer underneath the logs which are extending over the preloader, and then the beam of the preloader is lowered until the logs are carried by the tractor. Then the

Fig. 1. Portable boom on a spar

F. D. Helversen, Member TAPPI; Chief Industrial Engineer, Crown Zellerbach Corp., Portland, Ore.

Vanzyme discs

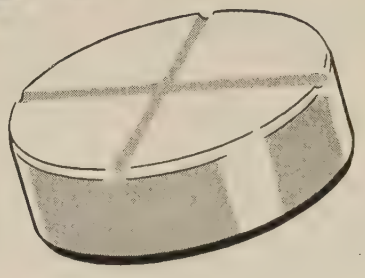

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Fig. 2. Air tongs for loading logs

beam of the preloader is rotated parallel to the axis of the tractor and trailer, and the load is ready to move.

Logging Skidder

The skidder, which is used in conjunction with the boom and spar for hauling logs to the loading station, is a rather complicated mechanism mounted on a carriage so that it can be moved rapidly from one spar to another. It is significant as far as material handling practices are concerned that a great shift in the Western logging industry has occurred, namely, from railroading to trucking on roads. Obviously trucking is much more economical because of its greater flexibility. The skidder is mentioned to illustrate the amount of thought which goes into material handling and transportation in Western logging operations.

Seed Cone Stripper and Seeding Device

A hemlock cone stripper was developed by the Crown Zellerbach Logging Department for the purpose of reducing the cost of obtaining hemlock seeds. This device has cut the cost of obtaining hemlock seeds by 66% and is now used throughout the United States. It was developed in 1949 and has received wide acclaim

Fig. 3. Air tongs loading logs onto a trailer

and use because it can be used for stripping all kinds of seeds in addition to hemlock seeds for which it was developed.

It is a very simple operation. The branches of the hemlock are put through a fence of nails. The nails strip the hemlock cones which fall into a sack.

While discussing seeds, I will take this opportunity to describe a seeding attachment on a helicopter. The seeds are loaded into a hopper, below which there is a mechanized counting device which discharges the seeds into an exhaust stream which propels the seeds past the landing wheels into the air so that they can fall to the ground.

In general the planting of seedlings costs the Crown Zellerbach Corp. about $15.00 an acre, and aerial reseeding costs about $5.00 an acre. The helicopter dispenses approximately 50,000 seeds per acre, of which we generally can expect 1000 to 2000 trees per acre, depending, naturally, upon the terrain, the soil conditions, and many other things which influence the seeding germination survival of trees. The Crown Zellerbach Corp. is just now measuring the success of helicopter seeding

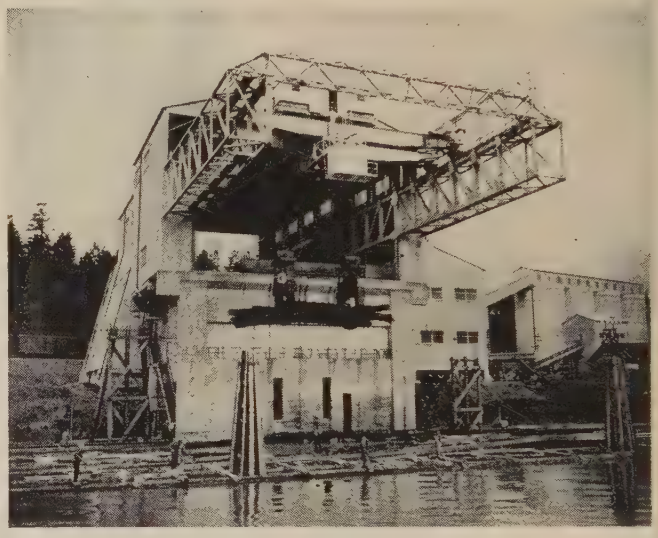

Fig. 4. Bridge crane used to lift logs from pond to log deck

and has not as yet come to any definite positive conclusion, but as far as the corporation has gone, the method seems to be feasible for future use throughout the United States. Helicopter seeding can be used for the distribution of seeds of any species.

Air Tongs

One of the newest log loading methods developed by the Logging Division of the Crown Zellerbach Corp., and in particular by L. N. Rees, Superintendent of the Clackamas and Cathlamet Divisions of the corporation, is a device called air tongs. These air tongs are mounted on the dipper stick of a conventional shovel. The Crown Zellerbach Corp. uses the air tongs for handling logs anywhere from 4 to 40 inches in diameter up to 48 feet long. The air tongs could be made larger to handle logs beyond the size of 40 inches and 48 feet lengths, but it is believed that the use of too large a unit would be uneconomical. The construction of the air tongs involves the reinforcement of the dipper stick, the installation of air piping and air cylinders, and the installation of a compressor in the cab of the shovel.

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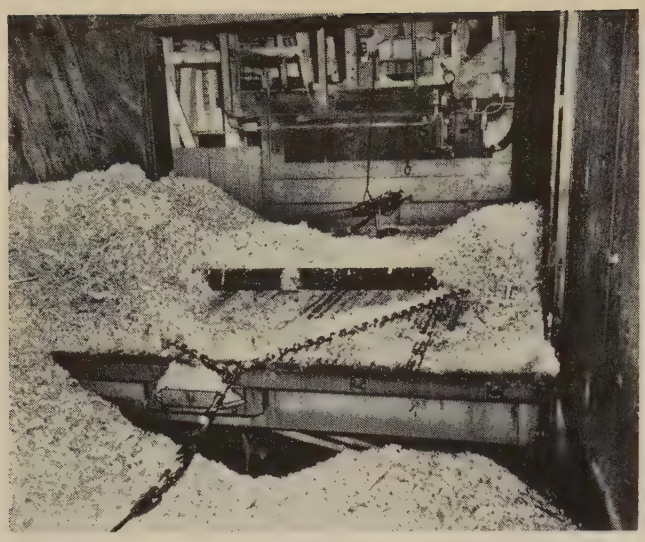

Fig. 5. Unloading chips from railroad car with a special rake

The air pressure used for operating the air cylinder is 80 p.s.i.

Figure 2 gives a view of the construction of the tongs and the simplicity of the device can be noted.

Figure 3 shows the complete material handling setup where air tongs load logs onto a trailer.

In the past, before the use of air tongs, a man called a "loader" was used on top of the trailer, helping to clear the logs. This position has now been eliminated. The savings made by the elimination of this man are small in comparison to the improvement in safety which was brought about by the use of air tongs and the elimination of one of the loaders. This loader's occupation was very dangerous because his legs were always subject to serious injury due to slipping logs.

Log Handling at Mill

The Longview Fibre Co. of Longview, Wash., has a squaring device for 8 foot farmers wood. One whole truck load of farmers wood is unloaded on a conveyor and the load is transported into the squaring device. When the load has been squared, the load is picked up by a grab, which has a capacity of $1^1/_4$ cord, powered by a hammerhead Colby crane. The grab, as well as the squaring device and the conveyor, are operated by one man who is in the crane.

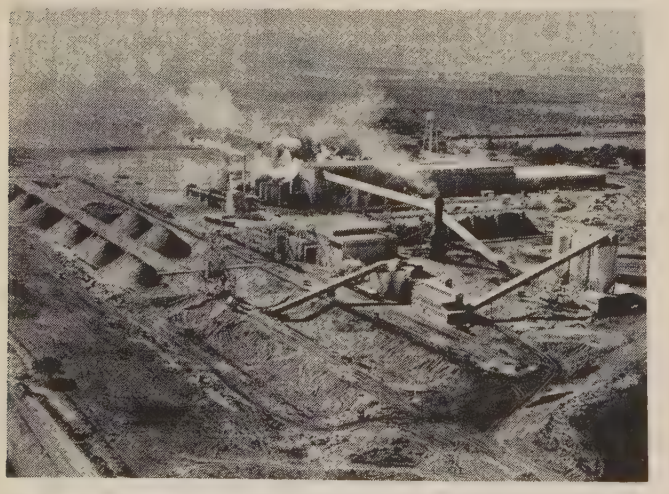

Fig. 6. Chip storage pits at the Fibreboard Product's mill in Antioch, Calif.

At the new wood mill of the Crown Zellerbach Corp. at Camas, Wash., whole bundles of logs are unloaded from the tractor and trailer and placed in the water by means of a crane.

The handling of bundle-type rafts at the mill in the past has presented a problem in that upon breaking the bands of the bundles, some of the logs would sink. Prior to the application of bundle-type rafts, the sinker problem was confined mostly to the raft booming areas at the logging operation. Transferring this problem to the mill operation caused considerable trouble, to the extent that it has been necessary to bring in a digger barge about once a month to remove sinkers from the log pond. In order to eliminate this problem, the equipment for handling logs to the deck of the new mill is designed along radical lines. The new mill does not have the conventional type of log haul or even the parbuckling type of hoist which is used in a few mills. Instead it is equipped, as shown in Fig. 4, with a Berger Engineering Co. bridge crane operating on cantilevers and having two hydraulically operated log grapples, either of which may be raised or lowered independently.

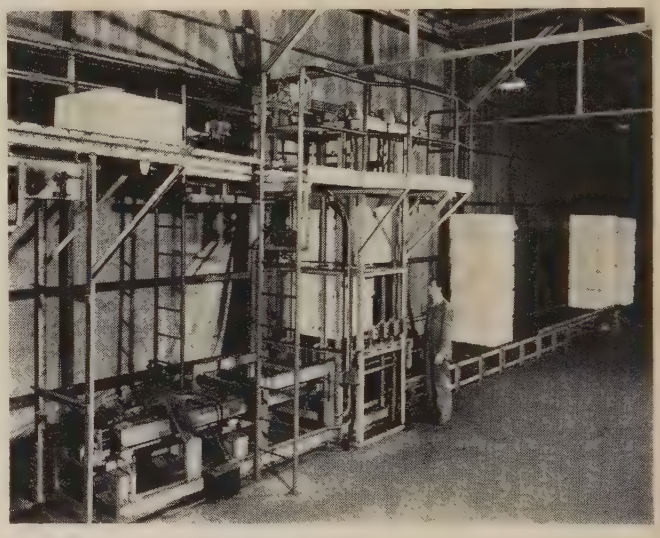

Fig. 7. View of a Mathews conveyor automatic stacking machine

A Berger wrapping hoist is provided to move the log rafts under the bridge in the crane grapples. This is a two drum hoist with speeds of 2, 5, and 20 f.p.m. on the hauling line, and 100 f.p.m. in the haul back line. It is remotely controlled some 150 feet away by the boom man.

The bridge craneway is approximately 270 feet long, 200 feet being above the log deck and 70 feet being cantilevered over the water of the Camas slough. The crane grapples are designed to handle bundle rafts up to 65-foot lengths, having a net weight of 100,000 pounds. The bridge crane rails are located at an elevation of 95 feet, and the log deck at an elevation of 63 feet. These elevations are above the mean level of the river. The water level ranges from a minimum of 2 to plus 38, but it is normally around a 10-foot stage. The hoists are designed for full hoisting speeds of 25, 40, 70, and 146 f.p.m., with a bridge speed of 100 f.p.m. and a trolley travel of 80 f.p.m. Hoisting power is provided by two 100-hp. motors, one for each grapple, with Westinghouse reactor-type control.

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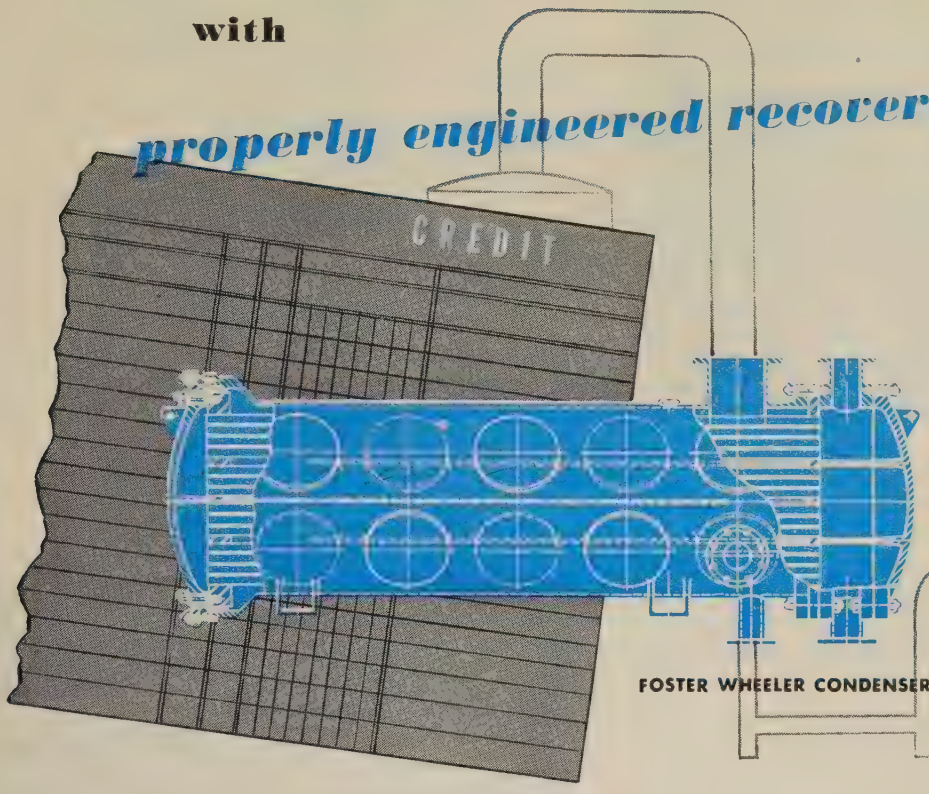

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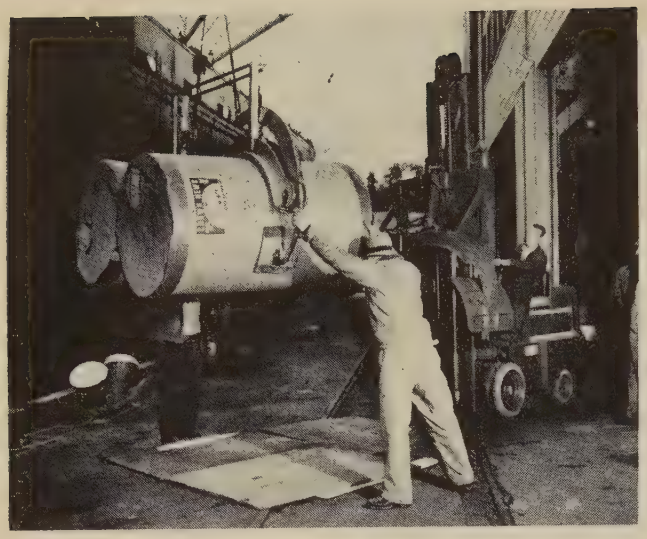

Fig. 8. Roll grab unloading newsprint from a ship

cally by means of a 40 hp. driven pump mounted in a waterproof casing on the grapple itself. The motor is supplied from a drum carrying Trytex cable which plays out or reels in at the same rate as the grapples travel. The grapples open to 14 feet wide and when closed will encompass a bundle of logs to 10 feet in diameter and can also pick up logs from a flat raft. The capacity of this equipment for handling logs will range from 50,000 board feet per hour when handling small loads up around 30,000 pounds net to a capacity of 90,000 board feet when handling heavy loads in the range of 80,000 pounds net. These capacities are established under maximum lift conditions, that is, when the river is at its lowest stage.

The bundles of logs are deposited by the crane on the transfer chains of the log deck. These chains carry the bundles to a series of pneumatically controlled arms which can be raised or lowered from the floor to encompass the bundle and hold it while the bands are cut. Upon removal of the bands from the bundle, the arms are lowered, allowing the logs to spill out onto the transfer chains of the log deck. From this point logs are transferred to a swing cut-off saw. This saw is a 100-inch diameter circular saw driven by a 75-hp. motor. Here the logs are cut into 24-foot lengths and are discharged to the transfer chain feeds into the hydraulic barker.

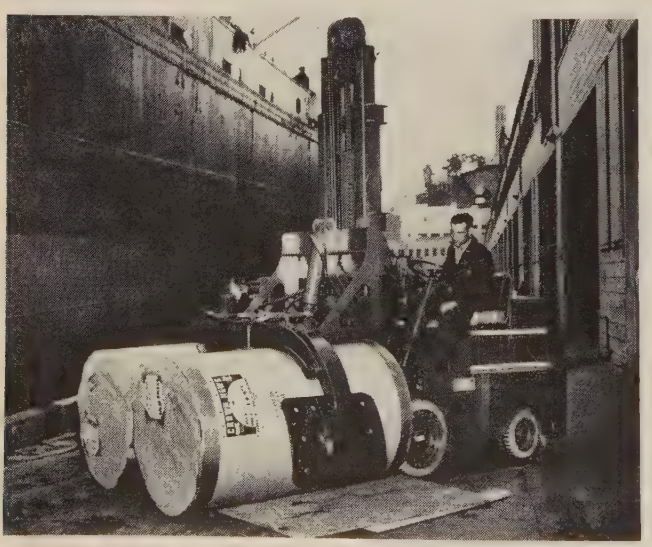

Fig. 9. Roll grab truck in place

The in-feed in the whole log chipper was manufactured by the Sumner Iron Works. The chipper is a 6-knife, 153-inch diameter, two-anvil chipper driven by a 1500-hp. motor. Logs up to 34 inches diameter can be processed in this chipper. One of the most remarkable features of these whole log chippers is their capacity. This 153-inch chipper, if supplied with logs of 30 inches in diameter end to end in a continuous stream, would convert to chips over 200,000 board feet of logs each hour. This chipper is the first large one over 110 inches diameter to be equipped with a sloping bed knife. This change was made in expectation of obtaining a quality of chips that would compare with the 110 inch and smaller chippers. The operator controlling the lowering of the log onto the chipper disk, can control the slipping of the first log in a manner which results in minimum shock on the chipper disk bearings.

The subsequent logs drop on the log being chipped without the use of the loading device.

Chips are discharged from the chippers to a 72-inch width rubber belt conveyor which transfers the chips to a concrete chip storage silo. There are four of these silos, each 44 feet in diameter by approximately 70 feet high. Each silo has a capacity of approximately 400 units of chips. Chips are discharged from silos by link belt mechanical feeders to a 42-inch belt conveyor which transports them to the screen room.

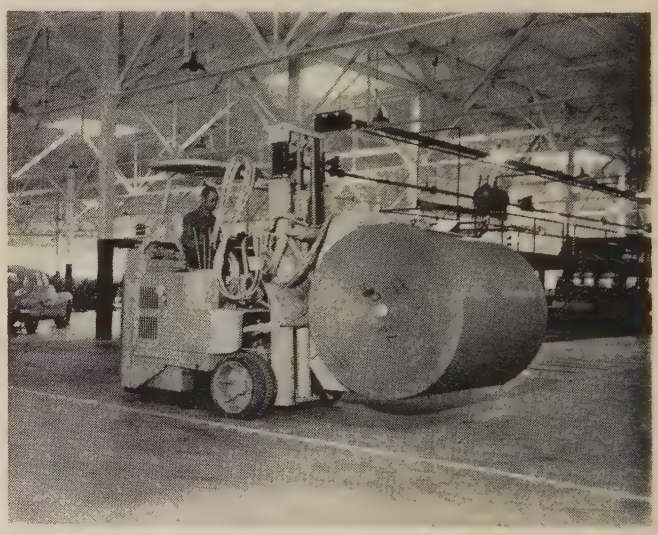

Fig. 10. A Peterbilt McDonald grab truck

Chip Removal from Railroad Cars

At the Longview Fibre Co. in Longview, Wash., chips are received in railroad cars which are owned by the company. In order to unload the cars rapidly, the Longview Fibre Co. has installed a permanent rake in the bottom of each car.

Figure 5 shows the rake and the method of fastening the cable to either side of the rake. The rake is pulled back and forth on the bottom of the car by means of a reversible winch, and in this manner chips are removed from the car and onto the conveyor.

Chip Storage and Handling at Mill

Figure 6 shows chip storage and chip handling at the Fibreboard Products' plant in Antioch, Calif. You see

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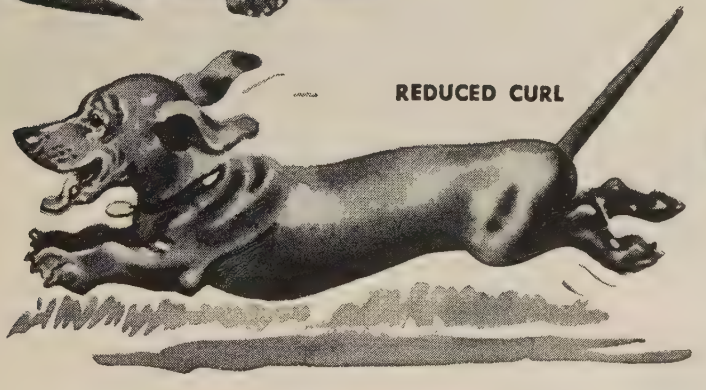

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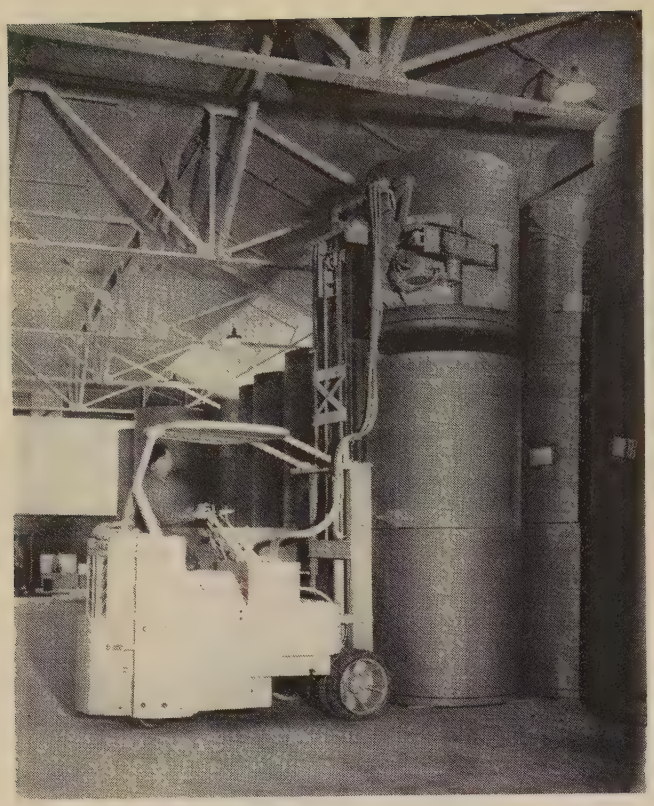


Fig. 11. Grab truck storing rolls in the warehouse

here two open trenches, each approximately 1400 feet long and 150 feet wide in which chips are stored in the open. Since Antioch is in California the climate permits storage of chips outdoors. The chip loading and unloading crane is Fibreboard Products' own design. The capacity of the unloading and loading crane is 12 units per hour. The main blower inside the crane is driven by a 150-hp. motor.

It was necessary to install chip storage facilities of this type because chips are received from the Eastern California lumber country by rail.

Connected with the chip loading and unloading crane are two go-devils which have a capacity of 3 units each. The chips are sucked either out of the railroad car or out of storage and discharged into the go-devils which transport the chips to the conveyor going into the plant.

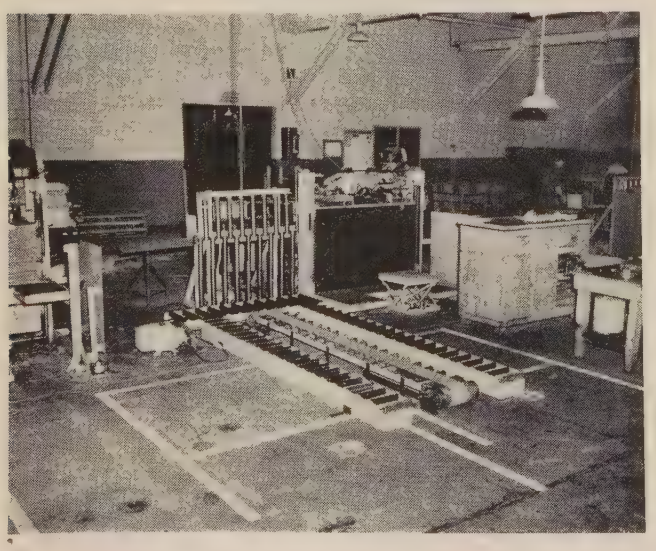


Fig. 12. Automatic conveyor feeding a box-stitching machine

The chips are loaded and unloaded by a crew of four men: one man handling the end of the pipe which either sucks chips out of railroad cars or out of storage, one man operating the blowers and/or conveyors of the unloading and loading device, and one man each operating the go-devils. This, indeed, is a very economical manner for handling 12 units of chips an hour.

Pulp Handling from Machine to Railroad Car

At the dry end of a Price-Barton pulp machine of 150-inch trim, producing bleached kraft pulp at the rate of 220 tons per day, the Weyerhaeuser plant at Longview has a layboy which automatically assembles stacks of pulp sheets of 400 pounds, each sheet 30 by 30 inches.

The layboy as well as the complete conveyor system, including the automatic stacker, was constructed by the Mathews Conveyor Co. of Seattle, Wash.

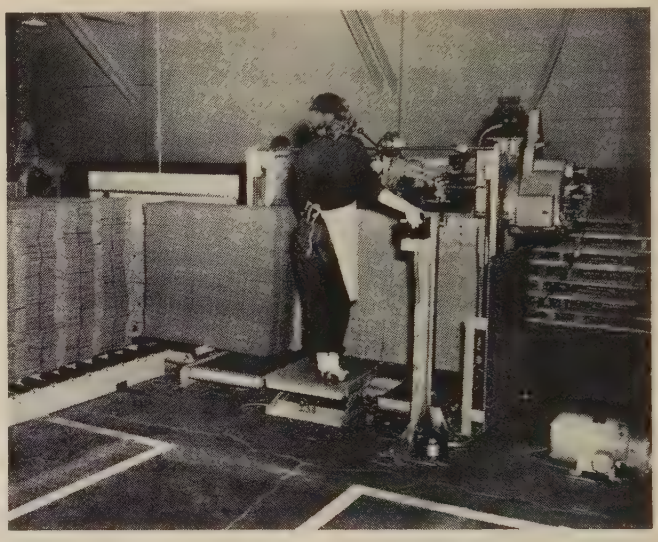


Fig. 13. Stitcher operator placing blanks into position

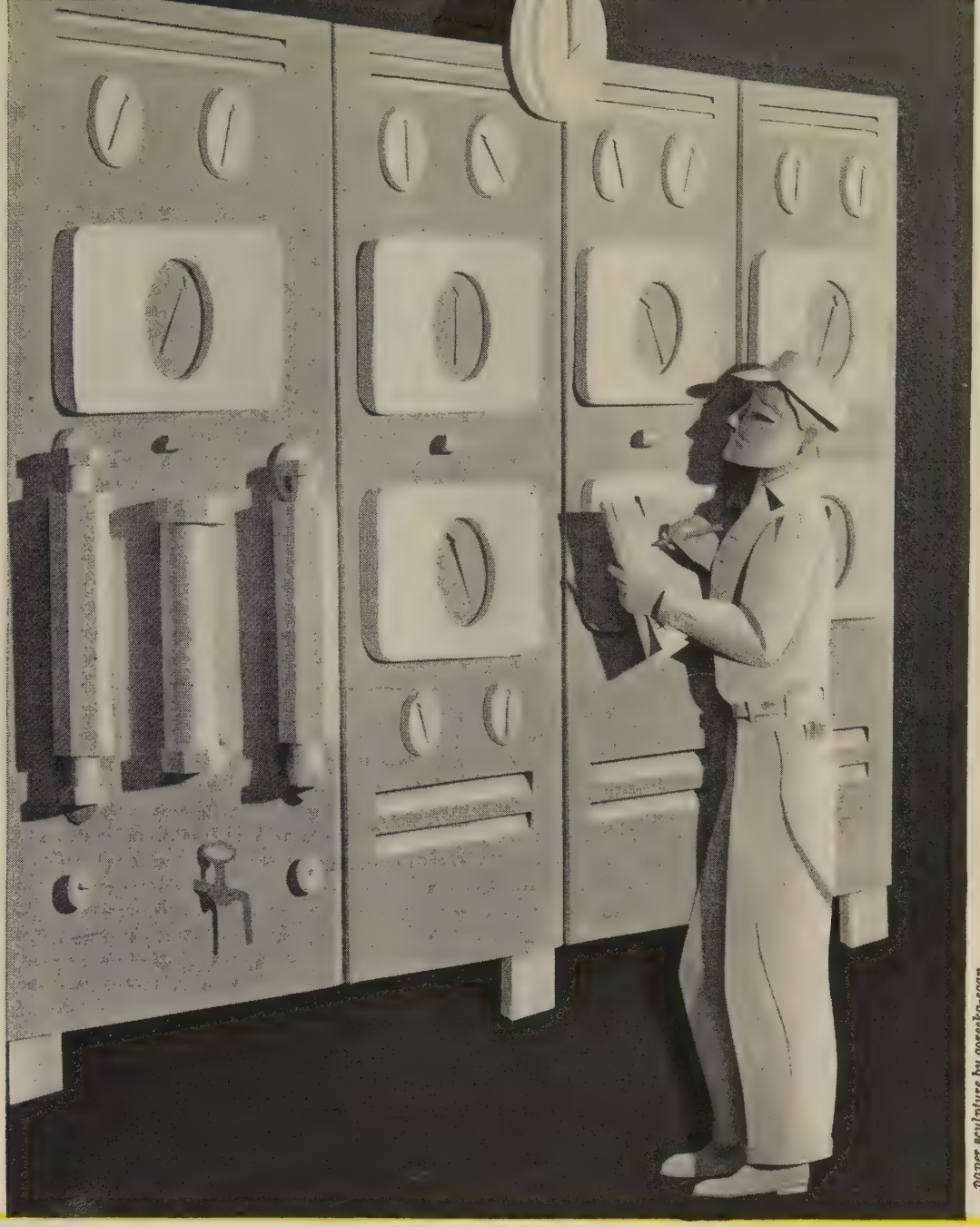
The conveyorized layboy discharges a stack of sheets onto another conveyor which turns the sheets in the direction of the pulp presses. Two baler men are required to push a bale of pulp into the press. The pulp is weighed before pressing. The presses are Baldwin presses of 600 tons each.

The finished bales coming off the pulp press and Parker wire tying machine are channeled from two lines into one conveyor and are automatically stacked five high by means of a Mathews conveyor automatic stacking machine (Fig. 7).

The printing and identification on the bales is automatically put on just shortly before the bales enter the automatic stacking machines.

As the last step in the operation, a fork truck operator takes the stacked bales and places them in the railroad car.

The finishing operation, that is, accumulating sheets on the layboy, discharging the layboy, running the bales through the presses and wire tying machines, stacking them, and loading them in railroad cars, requires two cutter men, two baler operators, and one fork truck operator, a total crew of five men. This is indeed a remarkable installation when it is considered that 73 tons of pulp per shift are handled by five men.



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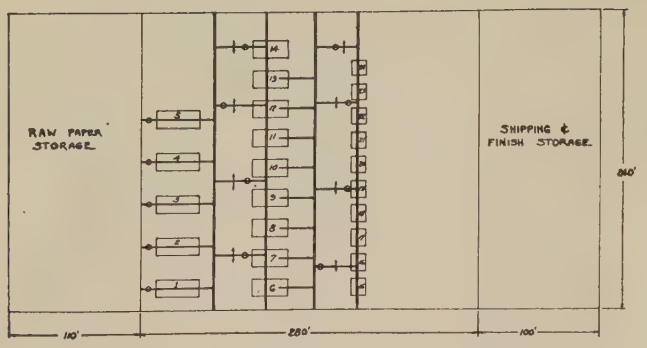


Fig. 14. Materials-handling system in one of the western waxed paper converting plants

Handling of Paper Rolls from Ship to Dock or Vice Versa

A double roll grab is used in unloading of rolls of paper from shipboard to dock or vice versa. The cables on the double-roll grab are attached to a cable from the unloading boom of the ship, and when pulled tight activate the clamps on either side of the grab. These grabs hold the rolls tightly in place while lifting them out of the hold onto the dock. This particular grab can handle up to 44-inch diameter rolls.

Figure 8 shows how this roll grab works when unloading newsprint from the ship. Also, you can see a double roll grab fork truck in the back, and in this particular case it is a Clark truck which has the Terminal Equipment Co.'s tilting double roll grab attached to it. The double roll grab attachment to the Clark truck is shown here with the permission of E. W. Horseman, President of the Terminal Equipment Co. of San Francisco.

Figure 9 shows the two newsprint rolls, seen in Fig. 8, placed on the dock, and the double roll grab truck maneuvered into place.

It should be emphasized that the tilting double roll grab as shown here is a separate piece of equipment developed by the Terminal Equipment Co. This grab can be attached to any truck of sufficient capacity. This double-roll grab has revolutionized newsprint handling at the San Francisco dock where it is used. The speeding up of this operation and the elimination of manual labor caused by this method of handling has been rather phenomenal.

Fig. 15. Handling paper in the warehouse

Handling of Large Diameter Rolls

At the Longview Fibre Box plant in Oakland, experiments were conducted with a Peterbilt McDonald grab truck handling 60-inch diameter rolls weighing approximately 5300 pounds each. These rolls are kraft board for solid fiber or corrugated cases. The truck is of 6000-pound capacity.

Figure 10 shows the truck rotating this roll, which is 60 inches in diameter, for placement in operating position, and Fig. 11 shows the truck storing the rolls in the warehouse. The Longview Fibre Co. is highly satisfied with the operation of the truck and has reported that no damage to rolls occurs. However, it is a requirement that the rolls be tightly wound.

Conveyor Application on Stitcher Machines for Box Manufacture

An automatic conveyor feeding a box stitching machine at Longview Fibre's box plant in Longview, Wash. is shown in Fig. 12.

The front part of the conveyor transports carton

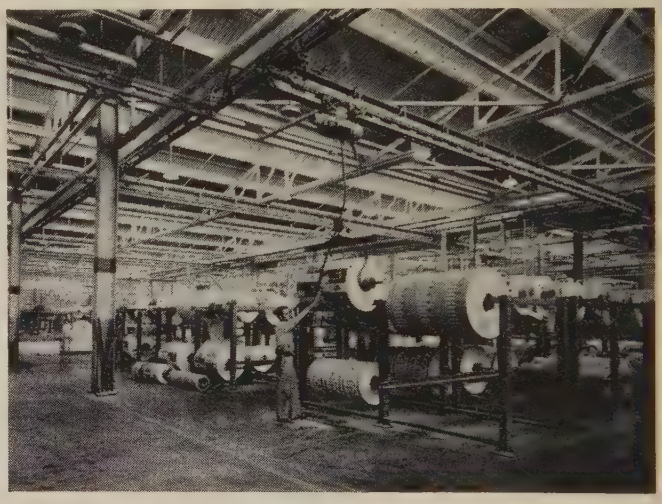


Fig. 16. Tramrail bridge handing paper between the presses and waxing machines

blanks to the back side, and the back side removes one stack of carton blanks in a manner which places this one stack in operating position for the stitcher operator. A fork truck places carton blanks on the front part of the conveyor.

Figure 13 shows how the stitcher operator removes the front stack of carton blanks and places it automatically in position for stitcher operations.

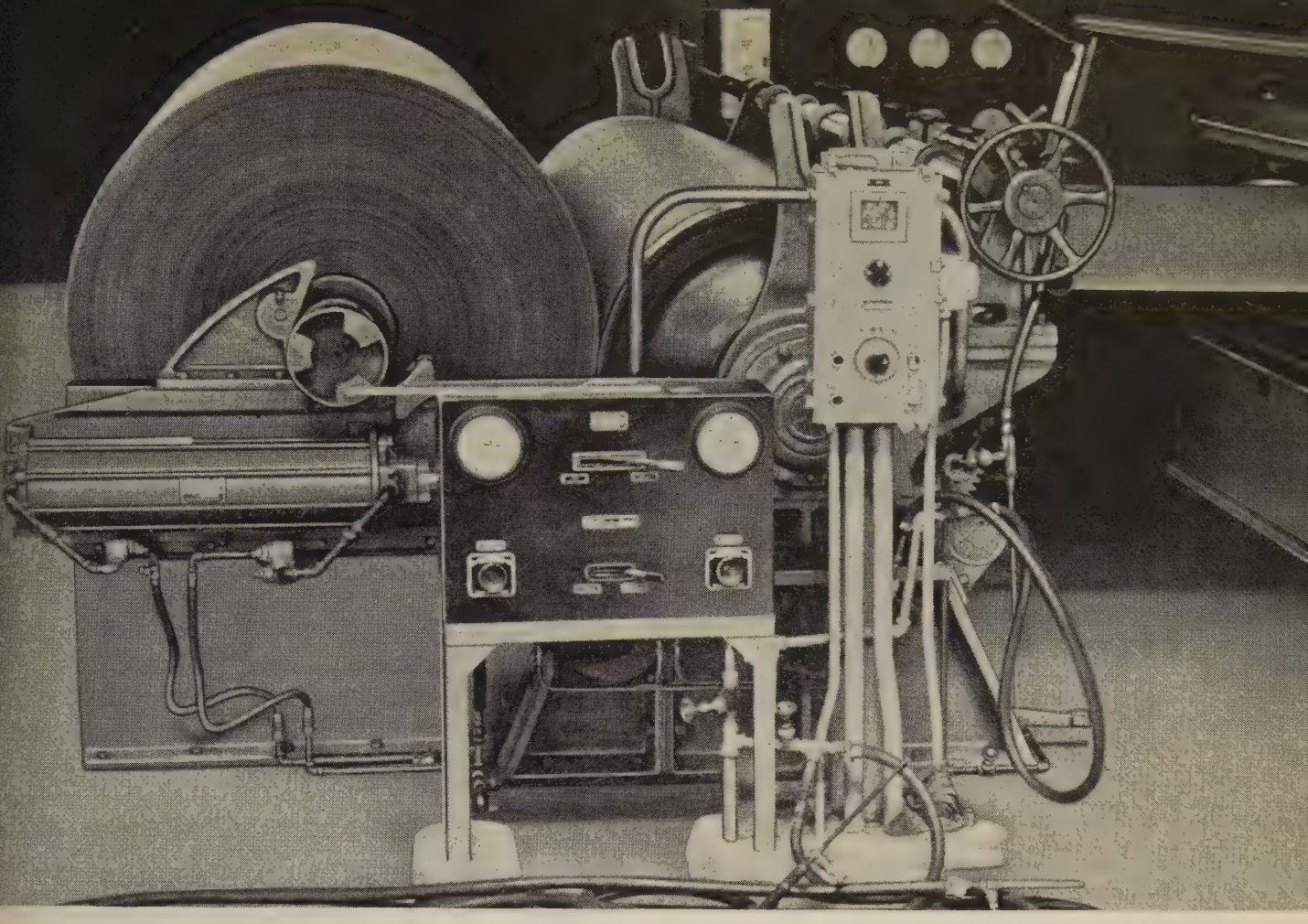
Material Handling in a Converting Plant

Figure 14 gives a schematic diagram of a modern material handling system in one of the Western Waxed Paper converting plants, Division of Crown Zellerbach Corp.

Raw paper is unloaded and brought into the raw paper storage by means of grab trucks and is transported by these grab trucks out of raw paper storage to the machines.

Material is handled from machines 1, 2, 3, 4, and 5 to any one of the machines numbered 6 to 14 and from the machines numbered 6 to 14 to any one of the machines numbered 15 to 24.

Machines 1 to 5 are printing presses; machines 6 to 14 are waxing machines, laminating machines, or other coating machines; and machines 15 to 24 are finishing



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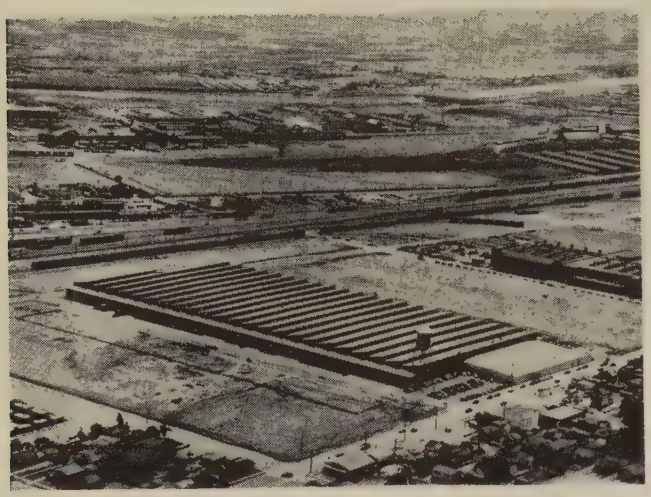


Fig. 17. View of the Zellerbach Paper Co.'s Los Angeles warehouse

machines such as rewinders, sheet cutters, spot cutters, die punches, etc. The material is fed into the first bank of machines by means of monorails and goes into temporary storage and onto the second bank of machines by means of a tramrail which covers the area as indicated. The material leaves by monorails from the second bank of machines and goes into temporary storage onto the third bank of machines by means of tramrails. The volume handled at this plant is approximately 1000 tons per month of a great variety of paper.

A grab truck (Fig. 15) stores paper in the raw storage warehouse and removes paper from the raw storage warehouse. Please note the 12-foot aisles which are necessary for speedy and efficient material handling of this type. Also note the height of storage of rolls without any pallets or blocking in between. The material is loaded onto and removed from presses by means of electric hoists on monorail.

Figure 16 shows the tramrail bridge handling the paper between the presses and the waxing machines. This installation consists of Cleveland tramrail equipment.

Material Handling System in a Paper Wholesale Warehouse

Figure 17 is an aerial view of the Zellerbach Paper Co.'s Los Angeles warehouse in the City of Los Angeles. The area of the warehouse is 400,000 square feet, and the office which is appended to the warehouse is 35,000 square feet, making a total area of 435,000 square feet. In the warehouse from 30,000 to 40,000 items are stored, and approximately 1600 orders consisting of 4800 items are handled a day.

The multitude of items stored and handled in the warehouse consists of resale merchandise such as stationery, variety goods, printing papers, and wrapping papers for consumer and industrial accounts.

The schematic diagram given in Fig. 18 shows the material handling layout in this warehouse. There are two chain floor conveyor systems operating in a trench at approximately 100 f.p.m. Number 1 line is approximately 3500 lineal feet and feeds the printing and wrapping paper departments. Number 2 line is approximately 1500 feet and feeds the stationery department.

The chain line in the floor has pusher dogs at approximately 16-foot centers, which provides for approximately 220 Nutting cars to be dragged by no. 1 chain and approximately 95 by no. 2 chain. The merchandise is delivered to this warehouse mainly by railroad cars and is shipped out on the opposite side from where it is received by trucks.

Figure 19 gives a closer view of how one of the Nutting cars is put onto the chain. The merchandise

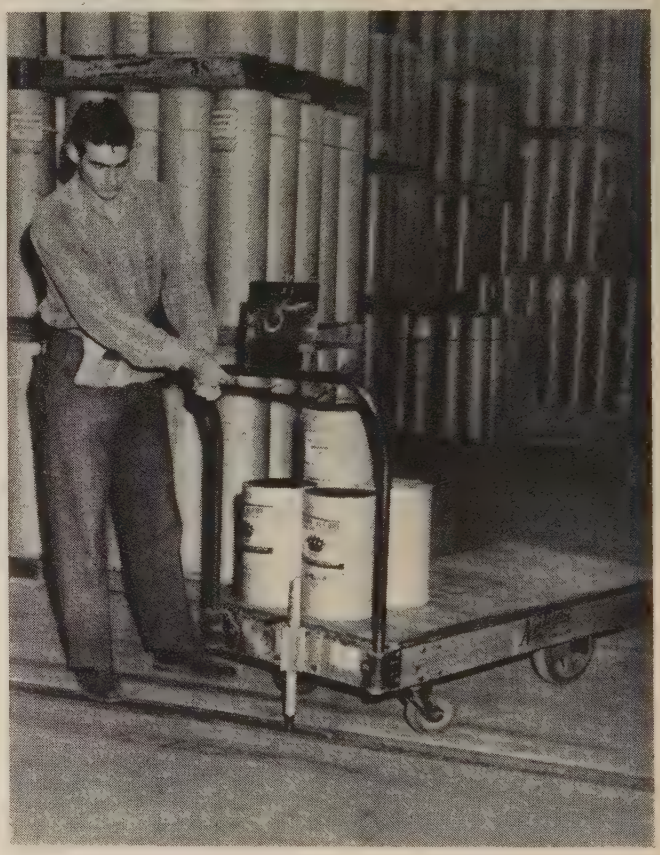


Fig. 19. Placing a nutting car on the chain

is loaded onto the car, and then the car is moved by hand to the chain in the floor. The pin drops by gravity into the slot in the floor, and the chain dog catches it and drags the cars along. When removing the car from the chain, all that is necessary is to lift the pin.

As can be seen this warehouse is designed to move merchandise from the manufacturer to the consumer at the lowest possible unit cost, which is the prime function of a distributor.

Unit Loads

The reason for including this subject in this paper is that it is possible that you may be able to help in

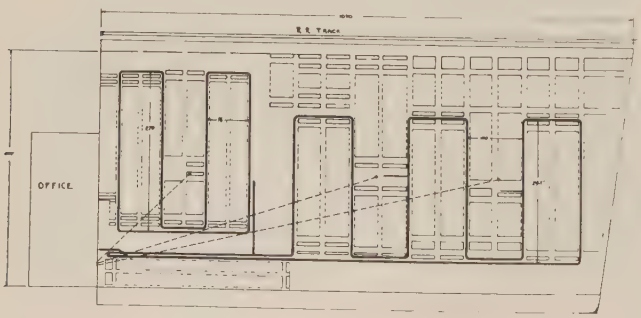
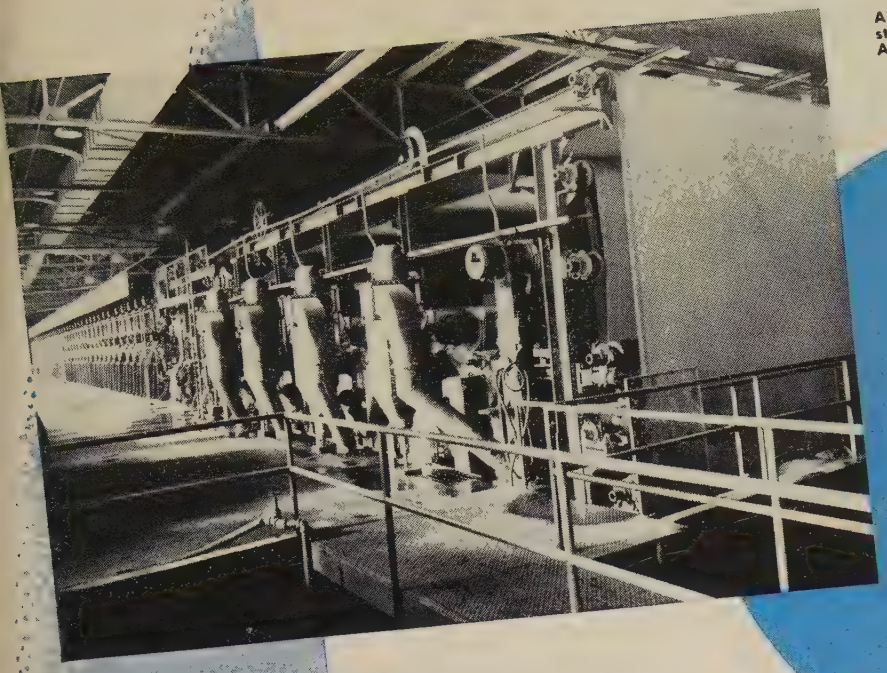


Fig. 18. Layout of the Zellerbach Paper Co. warehouse



Alton's No. 3 machine, world's record strawboard producer. Photo courtesy of Alton Box Board Company, Alton, Illinois.

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Fig. 20. Making up a unit load of towel cartons

solving the multiple problems associated with this experiment. Most of you have seen a badly loaded railroad car and we are conducting an investigation to prevent such conditions and also for the possible savings that may be obtained by improving the loading and unloading.

An example is the handling of cartons of Junior Certified Towels, as manufactured by the Crown Zellerbach Corp. The cartons arrive on a conveyor, and two stripes of glue are applied to the carton, one above the word "Certified" and one below the word "Towels." Then the carton is taken off the roller conveyor and put on top of a sheet of screenings, solid fiber, or corrugated board, whatever the case may be, and is glued solidly to the sheet.

In this experiment we have used Loadlock glue which is a special glue manufactured for this purpose. It has very high shear strength but practically no tensile strength, making it possible to remove cartons from the sheet of paper or from each other by just pulling.

The cartons are staggered as shown in Fig. 20 to give a nesting effect for making a real unit load. Here you can see how the two stripes of glue are applied to one side of the carton.

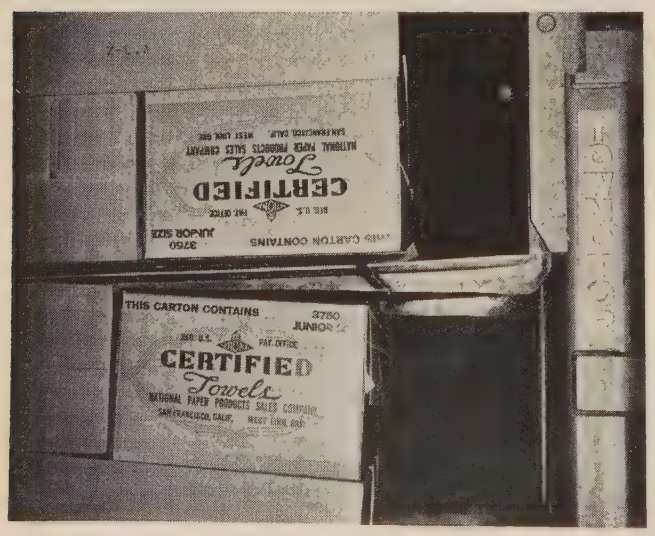

Fig. 21. Lifting a unit load with chisel-type forks

When making a unit load of 25 cartons in this manner you may ask, "How are you going to handle this load?" Here is the answer. A fork truck with chisel-type forks on top of which is welded a thin steel plate is used. The steel plate has a beveled edge. The plate is put in position under the lip. Then the plate is raised, lifting the edge of the unit load so that the plate and the chisel-type forks can slide in between this space. Figure 21 shows how it works—how the forks and plate slide in between the unit load.

It will take an experienced fork truck operator approximately 6 hours to get acquainted with this new method of handling unit loads, but once the driver gets the knack of it, no difficulties are experienced in handling these loads two high.

Figure 22 shows a car of unit loads arriving after a thousand mile trip. This is a view of the door opening, and the steel strapping has not yet been cut. Note the rather remarkable condition of the shipment. Practically nothing has shifted and nothing has been damaged.

We have not been successful as yet in making unit loads of counter rolls; mainly because counter rolls

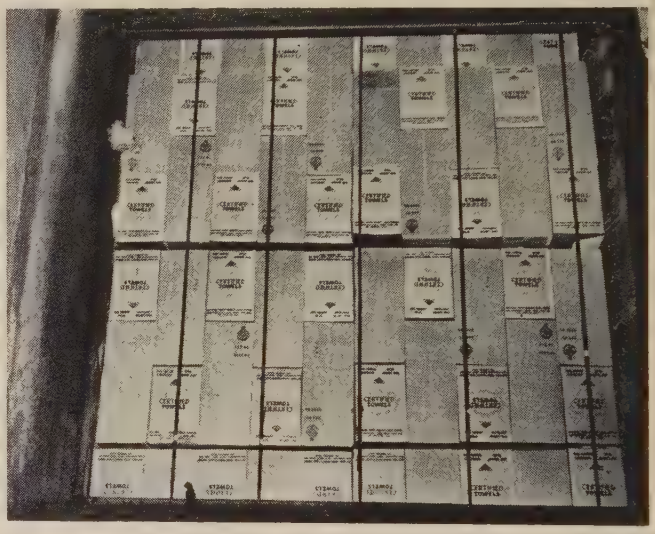

Fig. 22. View of unit loads in a railroad car after 1000 miles

vary slightly in diameter, and the gluing between them does not take hold for this very reason. Also, we have trouble in defacing the counter rolls when tearing them apart after they have arrived at their destination. The defacing is so bad that the wrappers are torn, and this is something which we feel should not happen.

This is entirely contrary to our experience with unit loads of cartons. Here a certain amount of defacing occurs, but never has it happened, as yet, that the carton is torn apart, mainly for the reason that the cartons consist of double-faced single corrugated, and one side of the corrugated gives way slightly. Merchandising men are of the opinion that this defacing of cartons does not make any difference when one takes into consideration the economies achieved by loading and unloading unit loads.

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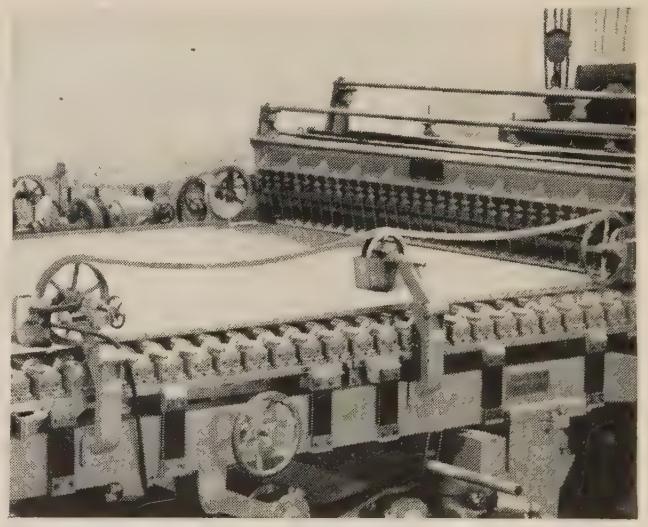

Fourdrinier section of paper machine with ANACONDA *Brass Rolls.*

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Standardization of Paper Machine Design

GEORGE E. CLINK

CONSIDERABLE thought is being given these days to the standardization of various parts of machines. It has been thought that the advantages of such standardization are far reaching. If this is true of manufacturing, why cannot it also be true that a standardization of various engineering factors relating to the paper machine would be possible with the same beneficial results to the industry. Recently, papers have been presented proposing the standardization of paper machine bearings. Also, a paper has been presented which proposed a standardization of power requirements. These are definitely steps in the right direction but it seems that we might carry our investigation even further back to the root of the problem in order that there may be an agreement in the trade on some of the basic requirements of design. For instance, what tension is carried on the fourdrinier wire? What tension is carried in a fourdrinier press felt and also in the board press felt? What line nip pressures are used on the various parts of the machine? Values for these factors must be found before the problem of design can be started. F. C. Huyck & Sons have done a remarkable job on the use of wet felt and the Pulp and Paper Manual of Canada have reported some interesting data on the newsprint industry. It is probable that much more work has been carried on which has never found its way into publication.

Some excellent research has been reported on some of these factors in the past but too often it is the work of an individual investigator and the results are therefore limited to a particular grade of paper. A correlation and completion of these data would be most beneficial. Let us study some of these factors individually and their effect on design.

WIRE TENSION

What do we know of wire tension on the fourdrinier? Besides its papermaking function, the fourdrinier wire has a mechanical function. It is a belt which must drive the table rolls, breast rolls, and under wire rolls. As the major load on a fourdrinier is probably the wire drag over the suction boxes combined with the turning of the various rolls, let us consider the probable wire tension due to its power transmitting function. Taking the power required to drive a fourdrinier and reducing it to torque and thence to a force acting at the circumference of the couch, we find that a force of approximately 17–22 lb. per inch is required to pull the load, hence a tension between the couch and suction boxes of 17–22 lb. per inch in the wire due to power alone. In order for the wire to pull this load without slip on the couch a certain slack side tension must be maintained and it is this tension with which we are concerned. It has been variously estimated at from 5–20 lb. per inch. If it is 20 lb., then the wire tension between the couch and suction boxes will be about 40 lb. per inch and if 5 lb., the tension will be about 25 lb. per inch. The lower this figure the longer the probable wire life.

Wire tension has very little to do with the design of wire roll bearings due to the slight wrap of the wire around the roll and also to the fact that for purposes of economy of manufacture, it is probable that the bearings are determined by the press felt rather than to have a special design for the few rolls located under the fourdrinier. Wire tension does however, have a function in the design of the fourdrinier breast roll, which must carry approximately 160° of wrap. If 20 lb. per inch tension is assumed, this means a loading on the breast roll of approximately 40 lb. per inch on the roll. This loading of the roll becomes even more critical as any deflection of the roll means that the edges of the wire are stretched by the amount of the deflection. It might also be brought out that crowning of the roll to take out this deflection would be of little avail unless the exact wire tension were known. It is entirely possible that some of the edge cracks on the wire may be caused by an excessive deflection of the breast roll.

The breast roll bearing would again be subject to the wire pull and hence their design would be dependent upon it. If 20 lb. per inch represents a fair percentage of the operating wire tension, then our assumptions of the past are correct. However, if they are running as low as 10 lb., it might be a consideration in new design.

FELT TENSION

The question of felt tension is probably of much more importance to the designer than the wire tension since it is this element which determines the design of all felt rolls and their bearings.

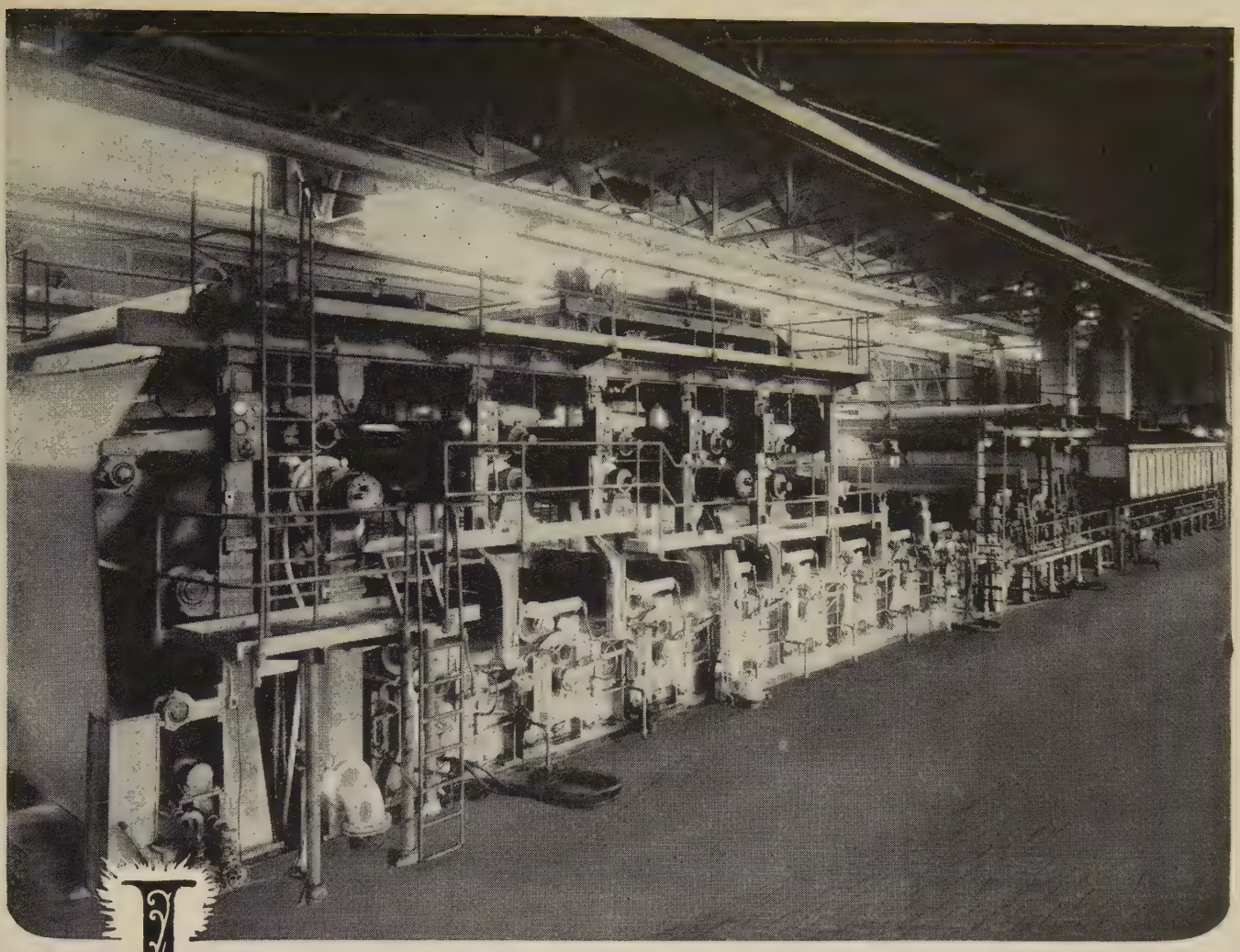
What do we know of tension in press felts? Probably the best research on this subject has been conducted by F. C. Huyck & Sons and published in their various Kenwood Bulletins. They went to some length to find the tension in the slack side of the felt at the stretch roll and they show a preponderance of values between 8 and 15 lb. per inch of width tension at this point and one exceptional case of 18 lb. per inch. The felt tension will vary considerably at different places in its run and also between types of machines.

The board machine felt is being used as a belt to drive the cylinder molds and primary presses and the tension in the felts will be high. For instance, on a seven cylinder board machine with three primary presses, there may be 50–55 lb. per inch tension between the first main press and the last primary press due to pulling the other parts of the machine and to this must be added the slack side tension of from 8 to 15 lb.

The Yankee machine pickup felt has a high tension as it has been found that part of the fourdrinier and main press load is transmitted to the Yankee by this felt.

The papermaker and mill manager are interested in this felt tension for several reasons. In the case of the board machine and Yankee machine, the felt manu-

GEORGE E. CLINK, Ass't. Supervisor of Engineering, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.



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facturer must design the felt to withstand these high tensions and the result is a compromise between optimum water-removal characteristics and a strong enough felt. F. C. Huyck & Sons in their Kenwood Bulletin No. 15, state that "Other factors being equal, the greater the tension the lower the water-removal." Figure 47 in this bulletin is very interesting as it shows graphically this relationship. It was noted that each time the felt tension was increased, water removal decreased and vice versa.

When the tension on a felt is increased, there will be a corresponding increase in the stretch and hence in those cases where the sheet is carried by the felt, the character of the sheet itself will be changed. The greater the tension, the shorter will be the life of the felt.

The engineer and designer are vitally interested in these factors since the various rolls and bearings must be designed to withstand the loads caused by felt tension. The tail roll on the Yankee machine may have a load of 80 lb. per inch as I have been told that one observer saw a couch motor entirely unloaded due to this tension. The board machine turning roll may have the same load and the rolls and bearings must be so designed. Helper drives have been placed on cylinder molds, drum rolls and primary presses to help relieve this condition. Press felt rolls are designed for a 180° wrap of the felt and the felt tension on the slack side is used as a design load. A small difference in the assumed felt tension makes quite a difference in the design load. On a 200-inch machine a difference of 5 lb. per inch in the tension changes the design load by 2000 pounds.

Drier felt tensions determine the design of the felt rolls and bearings. The bottom felt roll must withstand the combined load of 180° wrap of the drier felt plus the weight of the roll itself while the top felt roll takes the load of 180° wrap minus the weight of the roll. It is probable that both sets would be the same due to economies in quantity production. Here again, felt tensions of 20 lb. per inch have been assumed, however, cases have been found where it has been as low as 5 lb. per inch.

NIP PRESSURES

Nip pressures on main presses have received some study in the past from both the angle of water removal and also from the standpoint of felt life. The papermaker is probably most interested in actual nip pressure measured in pounds per square inch whereas the designer is interested in the line nip pressure expressed as so many pounds per linear inch of face. If the two rolls were perfectly inelastic, the actual nip pressure would be infinite as there would not be any area, merely a line. Such is never the case however, as all materials deform under load and hence there is an area of contact. For any line nip pressure, the actual nip pressure will vary directly as the hardness of the material in the rolls. Attempts have been made to measure the area of nip by inserting carbon paper between the rolls with various line pressures but the results are not as accurate as they might be and are difficult to determine so we more frequently speak of nip pressure in terms of so many pounds per inch of roll face which can be easily calculated.

The design of the rolls, bearings, framing, and loading device are determined by the intensity of this pressure. Theoretically, for each value of line pressure used, a different crown should be put on the press rolls. One of the functions of the rubber-covered press rolls is to minimize the effect of varying pressures.

Recently, a report of the electrical committee on "Power Requirements for Paper Machines" stated that the power required for a press was dependent on the line pressure used on the press. They stated that the constant given was for 175 lb. per inch. Recent investigations of our own show this to be true.

An article published in the "Pulp & Paper Manual of Canada" states that felt life on newsprint machines is reduced with higher nip pressures and this would probably be true of other grades of paper. Nip pressure then is an all important factor to the designer, papermaker and mill manager. However, how much information do we have on the pressures actually being used? The writer of the article in "Pulp & Paper Manual of Canada" stated that they were using 160 lb. per inch on a second rubber-covered suction press making news.

Another article in the same manual dealing with press sections gives 175 lb. per inch as the maximum, consistent with economical felt life. An investigation of another Canadian News mill disclosed a nip pressure of 123–144 lb. per linear inch on the first suction press and 141–150 lb. per linear inch on the second suction press. All of these values were for news being run at speeds in excess of 1000 f.p.m. A recent investigation on a machine making roofing felt showed a maximum of 187 lb. per inch. It would seem from this that 200 lb. per inch is a sufficiently high design load whereas it is not uncommon to design presses for 300 lb. per inch. This means that bearings on a 200-inch machine are being installed to take 5 tons greater load than required and the rolls to take 10 tons greater load.

Nip pressures at the cylinder couch, primary presses, size press, Yankee, and calenders are of equal interest but again the information available is meager, often the work of individual investigators and covering a small part of the industry.

RECOMMENDATIONS

I believe that we have shown that whereas some information on these factors is available, that it is incomplete and unsatisfactory. It would seem that this information could be collected, compiled and correlated to the benefit of the industry. In the past, it has been extremely difficult to determine these factors but with the advent of automatic stretches and pneumatic loadings, the job has been made possible. It will also be true that the value of these factors will vary, but it is also probably true that for different grades of paper and different types of machines that a pattern will be formed which will be very useful to the papermaker, engineer, and mill manager. Therefore, I would suggest that a committee of this organization be set up to study and tabulate the information at hand and submit a report at a later date which could be used as a tentative standard in order that everyone in the trade may be thinking along the same lines.

PRESENTED at the Fifth Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Oct. 2–5, 1950.

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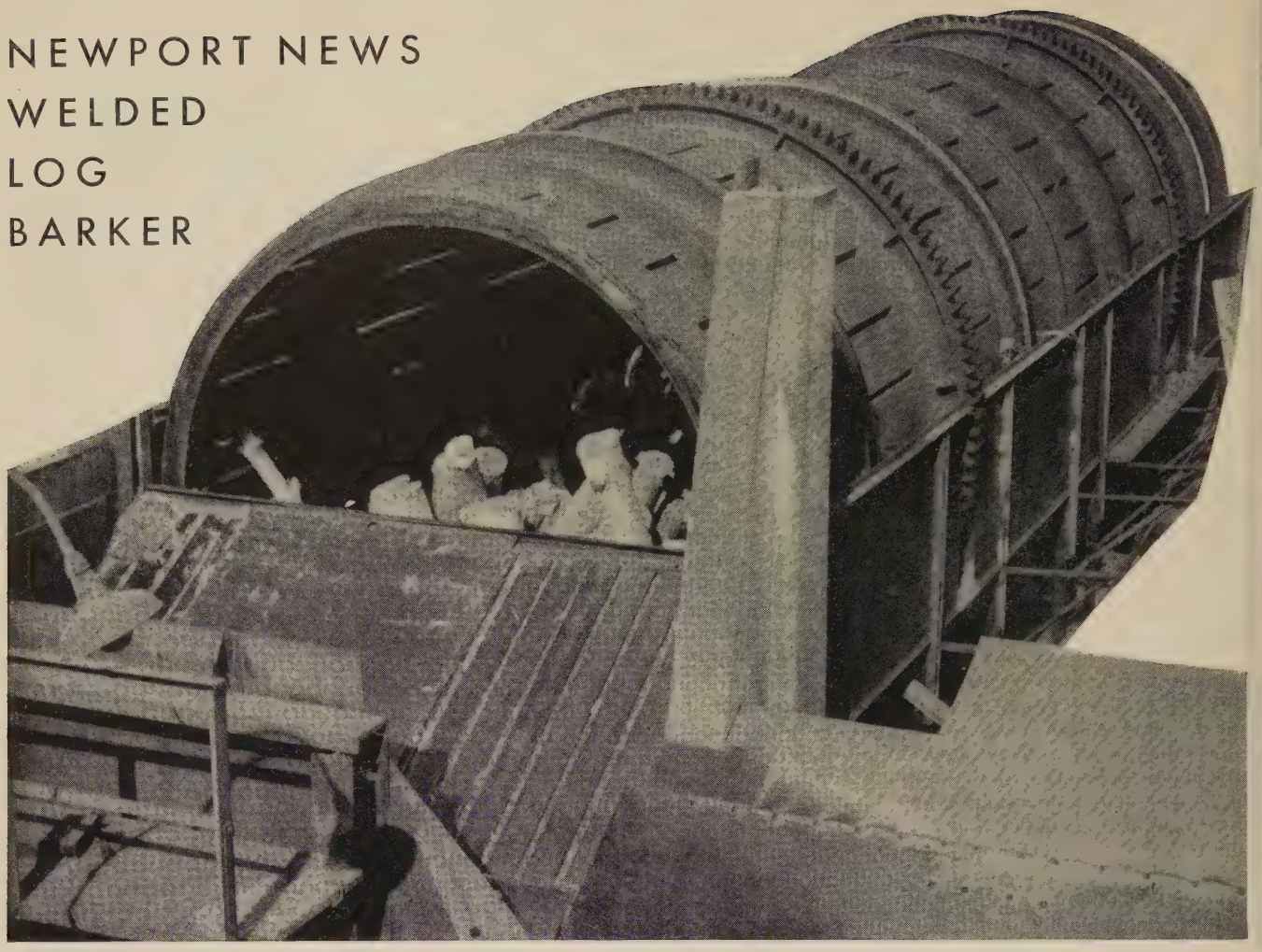

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The Newport News 45-foot welded log barker is constructed of two slotted drum sections weighing a total of 148,000 pounds. Incorporated in each section, which is fabricated from three 1¼″ steel plate rings welded together in halves, are heavy circumferential stiffener rings welded on the outside. Cast steel gears and forged steel rails form part of each assembly. Upon completion of assembly and welding, sections are completely annealed to relieve any stresses resulting from welding.

The sturdy construction of the Newport News barker is demonstrated by the rugged performance of two such units which have been in continuous service for almost two years in a large southern mill. Maintenance requirements during the period of operation of these units has been negligible.

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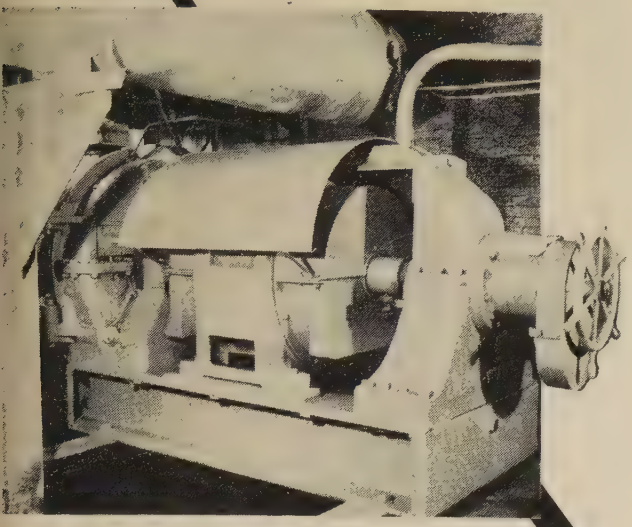
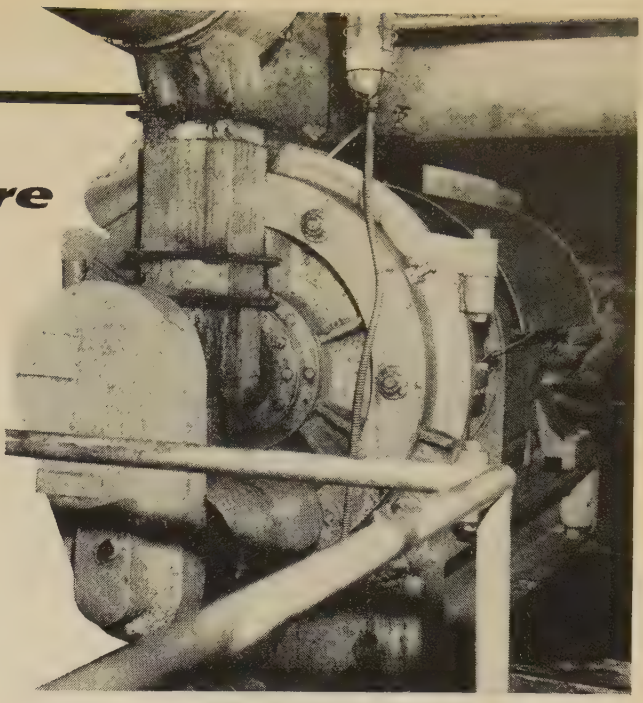


THE RUBEROID INSTALLATION

Sprout-Waldron Refiner Equipment at the Ruberoid Co., Gloucester City, N. J. plant



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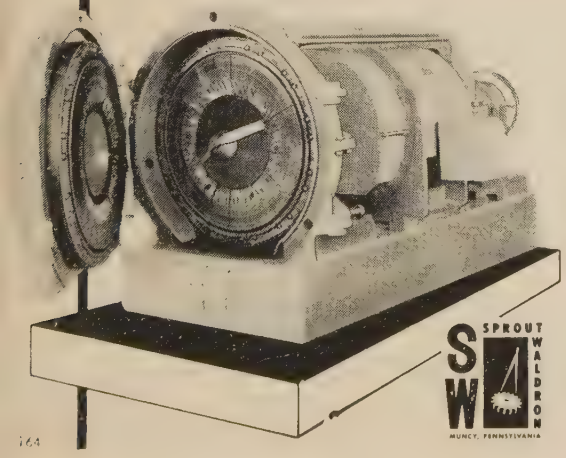

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Pulp and Papermaking Prospects in Western Colorado

JOHN W. PRINGLE and B. E. LAUER

The essentials for the development of a pulp and paper manufacturing operation on a moderate scale are all present in the Colorado area. The National Forests of the state can provide some 38,000,000 cords of mature and readily accessible green timber. In addition there are several million cords of beetle-killed spruce standing in a small area in the western part of the state. All of this should be removed entirely for pulping purposes. There is a good supply of water available from the Colorado River and several of the tributaries of this river west of the Continental Divide. The supply of coal for fuel is unlimited, and gas and oil fields are being developed rapidly. The development of federal reclamation projects is expected to increase the supply and decrease the price of electric power in Western Colorado. The railroad network is good for both interstate and intrastate shipment. Markets are available in the area; the newspapers, sugar producers, cement manufacturers, and agricultural interests offer the best immediate outlets.

With the present rate of consumption of wood exceeding, as it does, the regrowth and replacement of timber reserves, the pulp and paper industry must look to new areas in which to operate.

Among the existing undeveloped reserves of timber suitable for pulping operations, the vast areas of virgin forest in the Rocky Mountain states are becoming increasingly important.

COLORADO FOREST RESERVES

The ruggedness of the mountain terrain in the Rocky Mountain region has long been cited as the chief obstacle to the harvesting and utilization of the abundant timber stands. However, an extensive survey of the Colorado area alone made by the U. S. Forest Service in 1944 indicates that more than 38,000,000 cords of live, mature timber could be easily harvested from readily accessible areas in the National Forests of the state. In addition, there are several million cords of beetle-killed Engelmann spruce in rather compact stands in several of the forests. Most of this dead wood is in the more accessible regions where it can be logged easily. The dead timber, most of which was quite recently killed, will probably be satisfactory for the manufacture of pulp for at least twenty years.

Table I. U. S. Forest Service Figures—Operable Timber Volumes in Colorado—1944

National forest	*Total operable timber 10 inch and larger diameter trees, cords*
Arapaho	3,428,810
Grand Mesa	299,088
Gunnison	4,527,542
Pike	828,888
Rio Grande	4,577,865
Roosevelt	2,631,556
Routt	4,710,522
San Isabel	1,321,892
San Juan	6,631,660
Uncompahgre	2,167,620
White River	7,325,744
State total	38,451,187

The stands of green timber are good pulping species including Engelmann spruce, pondorosa pine, Douglas and Alpine fir, lodgepole pine, and other species in lesser quantities. Table I gives the volumes of operable timber of all species in the respective National Forests of Colorado.

Figure 1 shows the location of the major forest areas in the western half of Colorado. This so-called Western Slope area was selected for study since the water supplies east of the Continental Divide are insufficient to

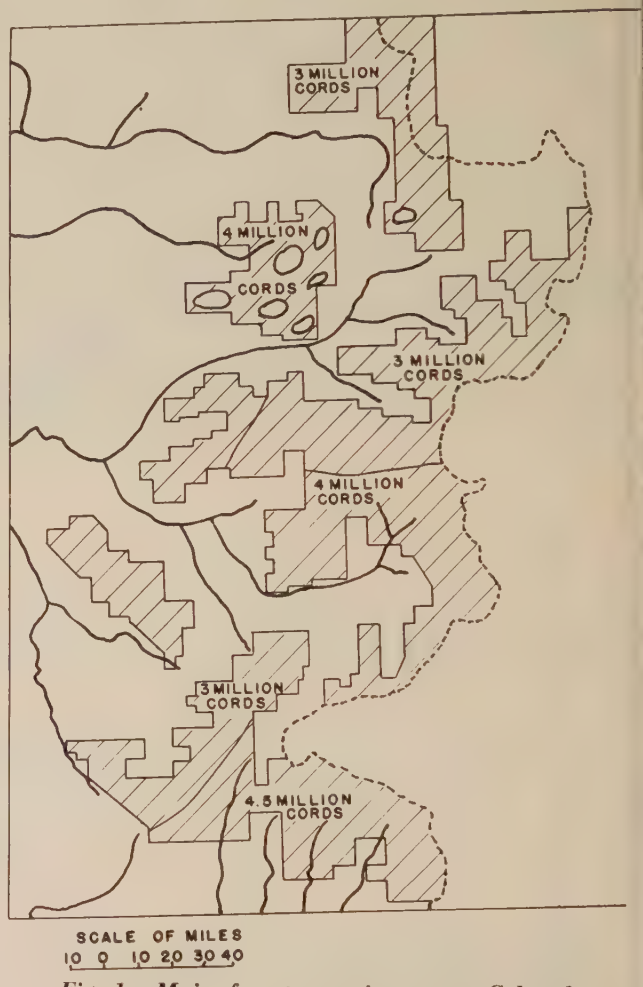

Fig. 1. Major forest areas in western Colorado

Operable volumes shown give an annual cut of 20,000 cords per million cord stand.

supply all agricultural demands and would probably not be available in adequate quantity for pulp mill use.

WATER AVAILABILITY

In connection with any large-scale pulping operation, large amounts of process water are of prime importance. In this item, the Western Slope of Colorado has an invaluable reserve. At the present time, over 2 million

John W. Pringle, Research Fellow, Department of Chemical Engineering, University of Colorado, Boulder, Col.
B. E. Lauer, Professor and Head, Department of Chemical Engineering, University of Colorado, Boulder, Col.

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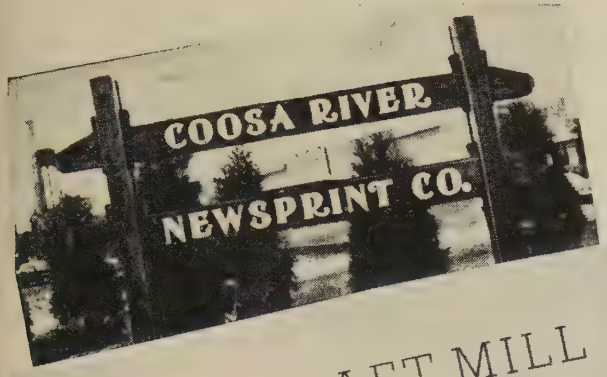

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acre-feet per year of water which has been allocated by the Upper Colorado River Basin Compact for use within the state of Colorado flows out of the state because of

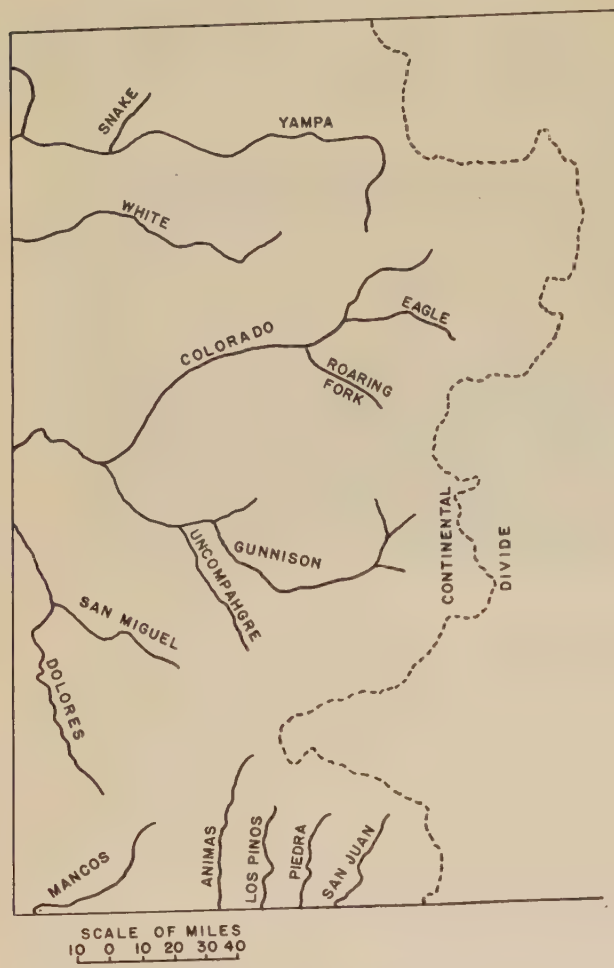

Fig. 2. Major rivers in western Colorado

Rivers shown have minimum flow over five times that required for 100 tons daily capacity.

lack of industrial and agricultural developments to use it. This water is a part of the some 3,500,000 acre-feet per year of water actually consigned to Colorado by the Compact, enacted as a legal statute by the United States Congress in 1949. The available water flows principally in the Colorado River and its Colorado tributaries, all Western Slope rivers. Table II shows the average annual flow of some of the principal rivers in this and other Colorado stream systems. It should be recalled that the production of 100 tons of chemical pulp will require about 10 million gallons of water.

Of the 3,500,000 acre-feet per year allocated, the present average annual use is reported by the Colorado Water Conservation Board to be about 1,300,000 acre-feet. The remainder is available for consumptive use by agricultural and industrial developments, and for trans-mountain transportation to drainage basins on the Eastern Slope. The diversion of water from its natural basin, however, is subject to prior commitment for consumptive use within the natural basin.

Most of the larger streams of the state, such as the Colorado River, Gunnison River, Eagle River, Roaring Fork, White River, and others, even at minimum flow deliver quantities of water at least several times the amount sufficient to provide process water and adequate dilution for the waste materials from a large pulp mill.

Table II. Historic Mean Flow for Colorado Rivers. Colorado Water Conservation Board—1948

River	*Station*	*Average flow* — *1000 acre-feet/ year*	*million gal./day*
Animas	Durango	654.7	585
Colorado	Hot Sulfur Spring	476.7	465
Colorado	Glenwood Spring	2080.4	1860
Colorado	Cameo	3505.0	3315
Dolores	Gateway	788.1	705
Gunnison	Grand Junction	2054.9	1837
La Plata	Colorado line	30.9	28
Snake	Lily	472.4	422
Navajo	Edith	131.8	118
Piedra	Arboles	380.6	340
Pine	Ignacio	256.4	229
Plateau Creek	Cameo	186.3	168
Roaring Fork	Glenwood Spring	1028.0	918
White	Meeker	461.7	412
Yampa	Steamboat Spring	345.1	308
Yampa	Maybell	1189.5	1016

In Fig. 2 there is shown the location of the rivers having adequate flow rates to support a large pulp mill. Only that portion of each stream is shown over which this flow rate is sustained.

RAILROADS

The railroad and highway networks covering Colorado

Fig. 3. Railroads in western Colorado

are quite complete, and the railroad system is particularly good along the principal waterways. The trans-mountain service between eastern and western

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In South Gate, California and Clark, New Jersey, United States Gypsum Company is operating the two largest combination felt and liner board machines in the world. One has 8 vats and 91 dryers, 361 feet long. The other is still larger, with 10 vats, and 124 dryers, 435 feet in length—approximately the height of a 35- or 40-story skyscraper. Downingtown Manufacturing Company built both machines and called upon Manhattan to furnish all rubber covered rolls, rubber covered Oliver Saveall's and rubber hose . . . 37 tons of rubber are employed in these two huge installations for the production of roofing felt and liner for gypsum board.

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shipping terminals has been greatly improved in recent years by such additions as the Moffat Tunnel, many miles of double track, and other major improvements in the railway system of the state.

The principal operating railroad in Western Colorado is the Denver and Rio Grande Western Railroad which has connections in Denver, Colorado Springs, Pueblo, Grand Junction, and Montrose to all market areas in Colorado and the surrounding states. Freight commodity rates published by this railroad indicate that competition with papermaking concerns, located on the Pacific Coast, Gulf Coast or Great Lakes areas, is possible on a freight basis over an area which includes most of the Rocky Mountain Empire and the Southwest. Figure 3 shows the railroad network in Western Colorado. The composite map of the same area, Fig. 4, shows the contiguity of forests, rivers, and railroads.

FUEL SUPPLY

Regardless of the quantity of fuel required, it is available in Colorado. Actually the supply of coal in Colorado is unlimited. A great portion of the state, particularly again the Western Slope area, is underlain by extensive coal fields. These are well developed along the principal waterways and railroad lines. Coal of good quality can be delivered to almost any point in the state with a haul of less than 100 miles.

It has been estimated that electric power can be produced at many locations within the state on a scale

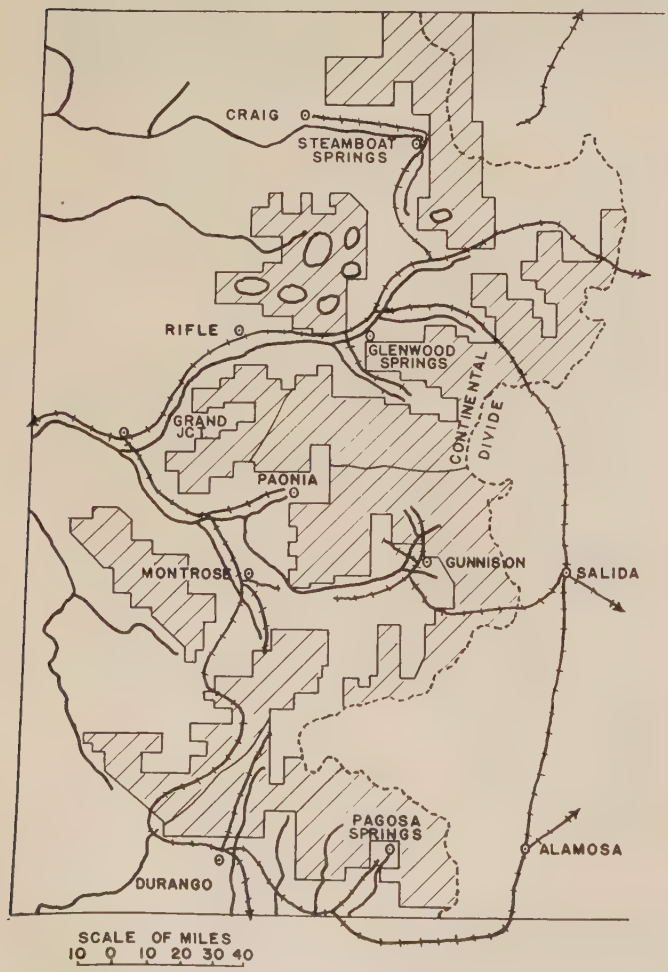

Fig. 4. Composite map showing forests, rivers, and railroads in western Colorado

such as might be required for a pulp mill for 4 mills or less per kilowatt hour by using coal as fuel. This is somewhat less than the present rate set by the Public Service Company of Colorado, the major operating power company in the state. With natural gas fields being developed within the western half of the state, even lower cost power is an immediate prospect.

The development of several planned flood-control and water-storage projects by the Bureau of Reclamation will also make large amounts of electric power available at rates considerably below those presently existing.

LOCAL MARKET PROSPECTS

There is an excellent local market in Colorado and surrounding trade areas for a considerable quantity of newsprint, kraft wrapper and bag stock, cartons, and miscellaneous specialty paper products. A large and aggressive newspaper, the Denver Post, an active sugar industry, several cement manufacturing plants, and a number of fruit and vegetable producers associations are all major users of paper products. The aggressive and growing communities of Salt Lake City, Ogden, and others in that area, as well as Denver and surrounding Colorado communities, would definitely lie within the trade area of a paper mill located on the Western Slope of Colorado.

Not to be overlooked is the fact that the development of the shale oil production in Western Colorado is progressing rapidly, and it has been estimated that when this area goes into full scale production there may be an increase in population of as much as 350,000 in Western Colorado. This, in itself, would be a sufficient number of people to use the products from a reasonable sized paper mill.

SUMMARY

The position of Colorado may be summarized as follows: over 38,000,000 cords of mature green wood are available for immediate harvesting in the National Forests, only the easily accessible and operable volumes being reported. There are, in addition, over 2,000,000 cords of beetle-killed Engelmann spruce in dense stands which should be removed from the forests immediately. There is an abundant water supply for year-round use and adequate amounts of coal available at low cost. Electric power is available now, and future power developments should bring substantial reductions in its cost. Transportation facilities are quite adequate for both interstate and intrastate shipment. Moderate markets are possible at the present time and should grow rapidly as Colorado and the Rocky Mountain Empire grow in industrial development and population.

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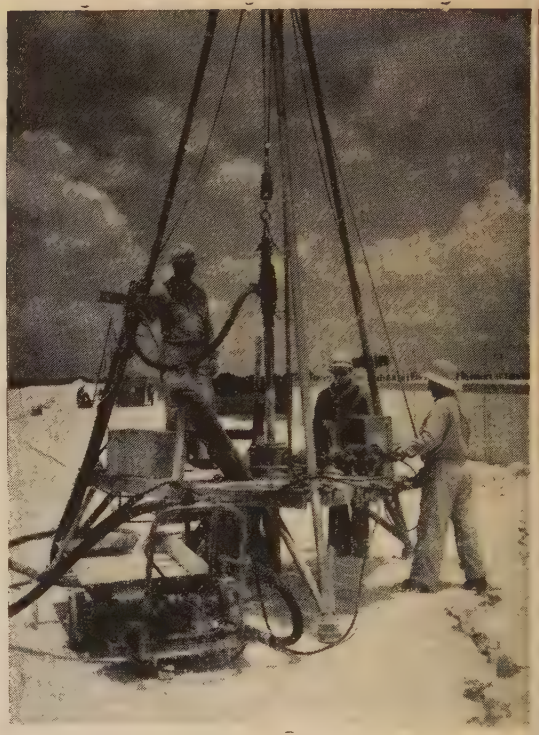

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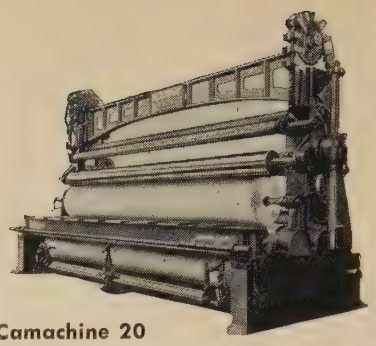

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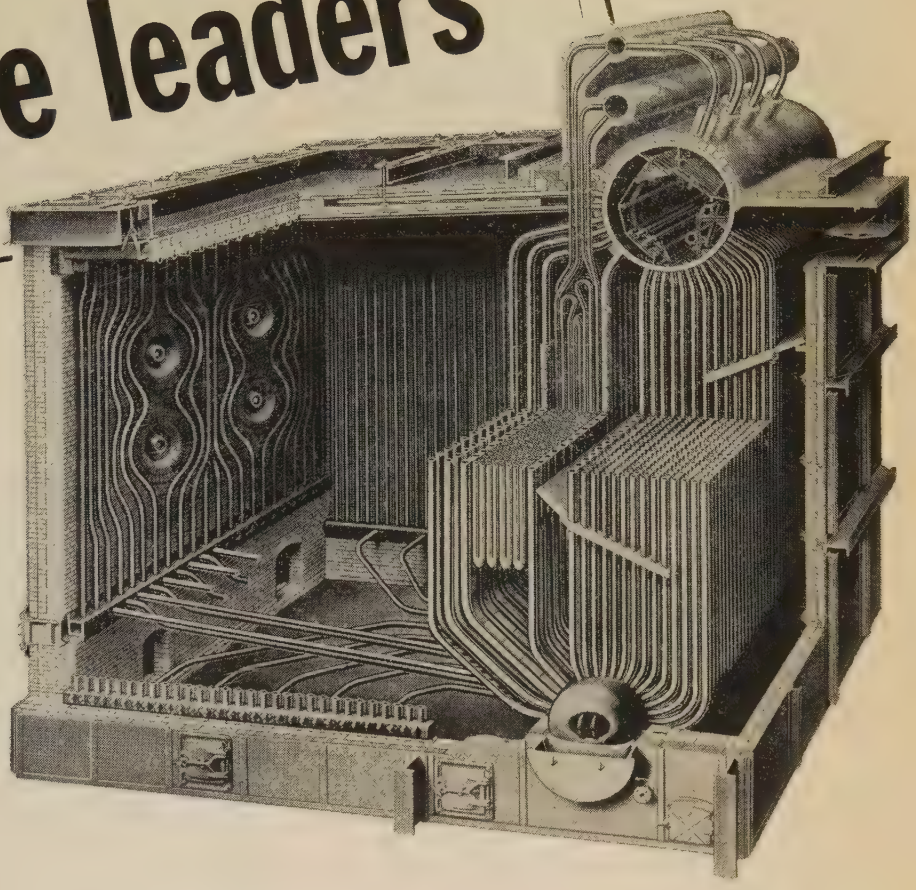

A partial list of pulp and paper companies that have purchased C-E Vertical-Unit Boilers for one or more mills.

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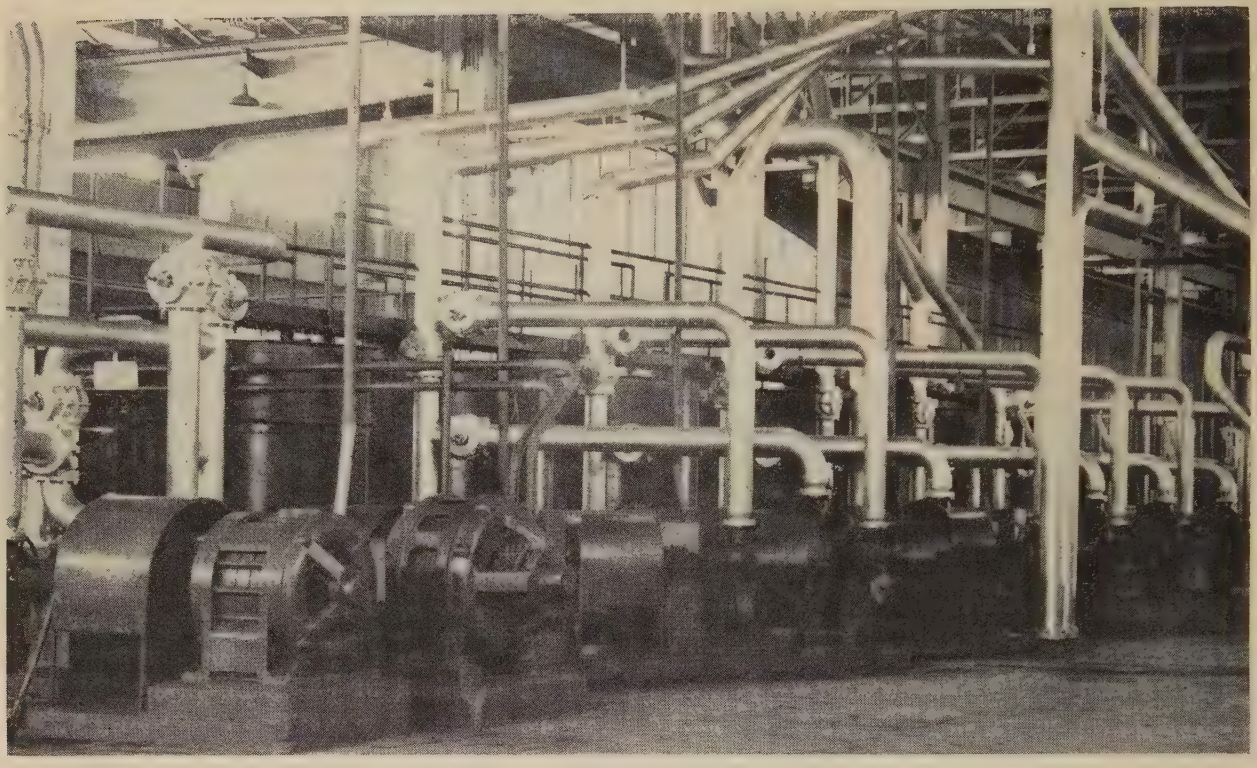

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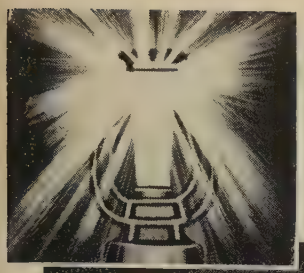

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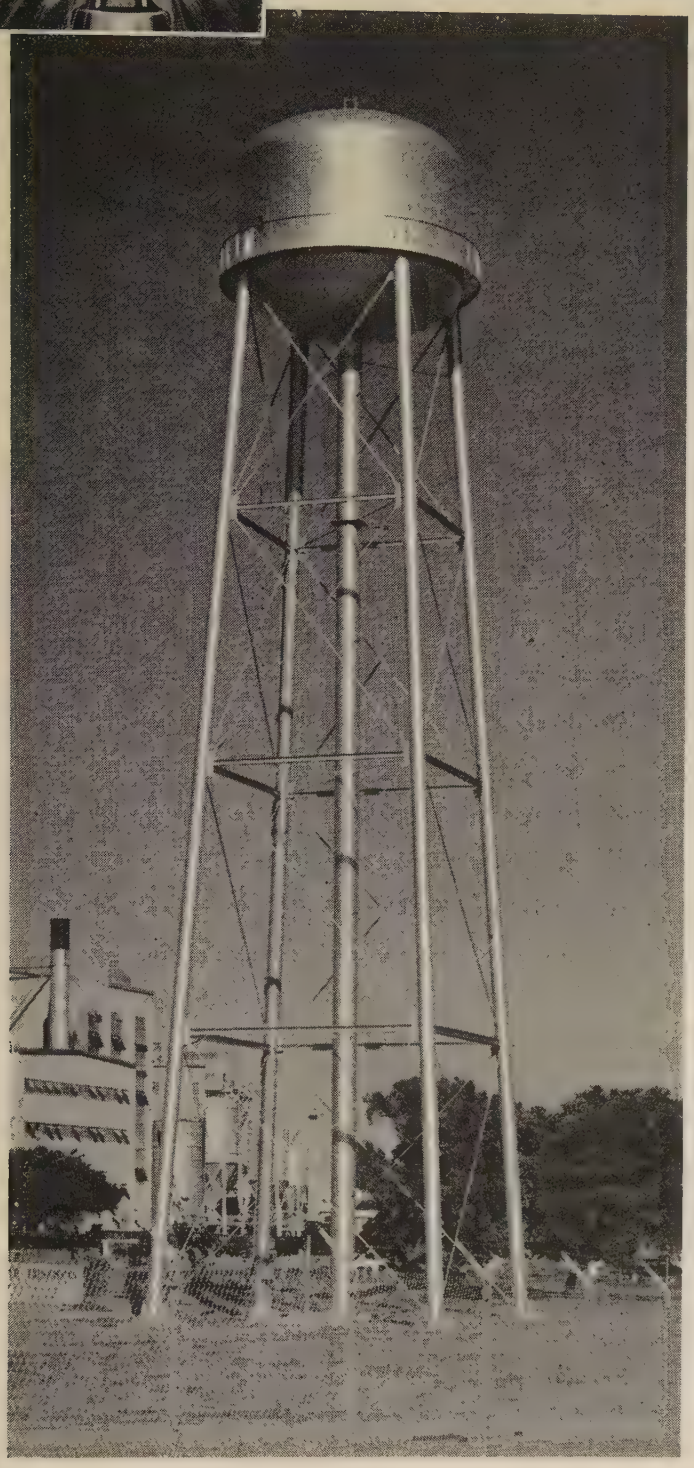

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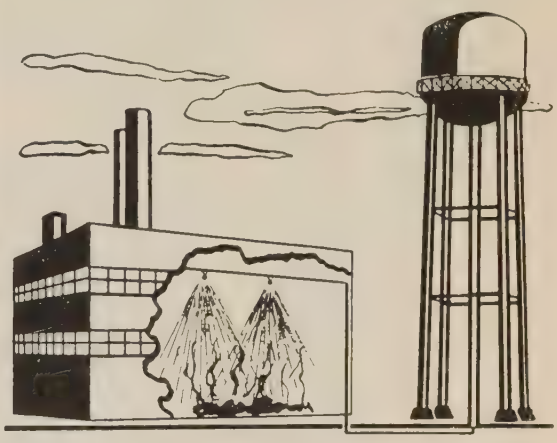

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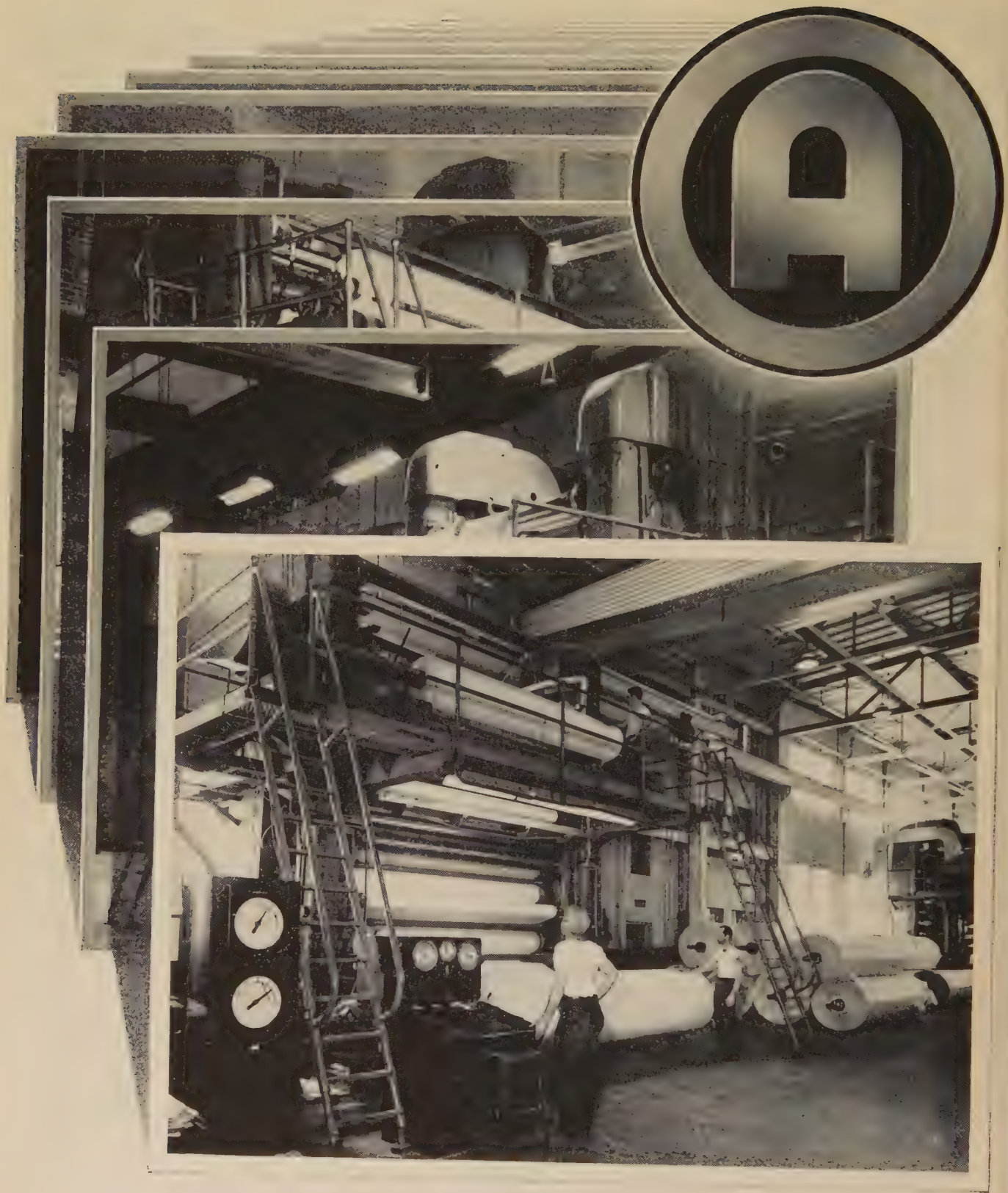

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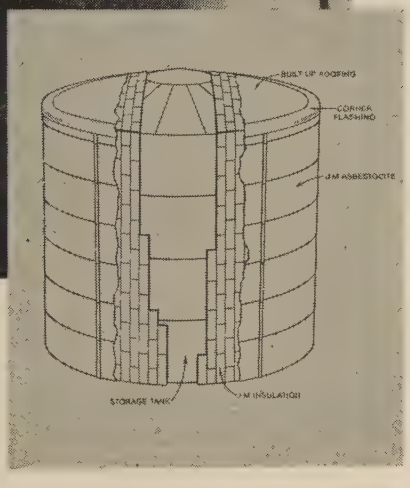

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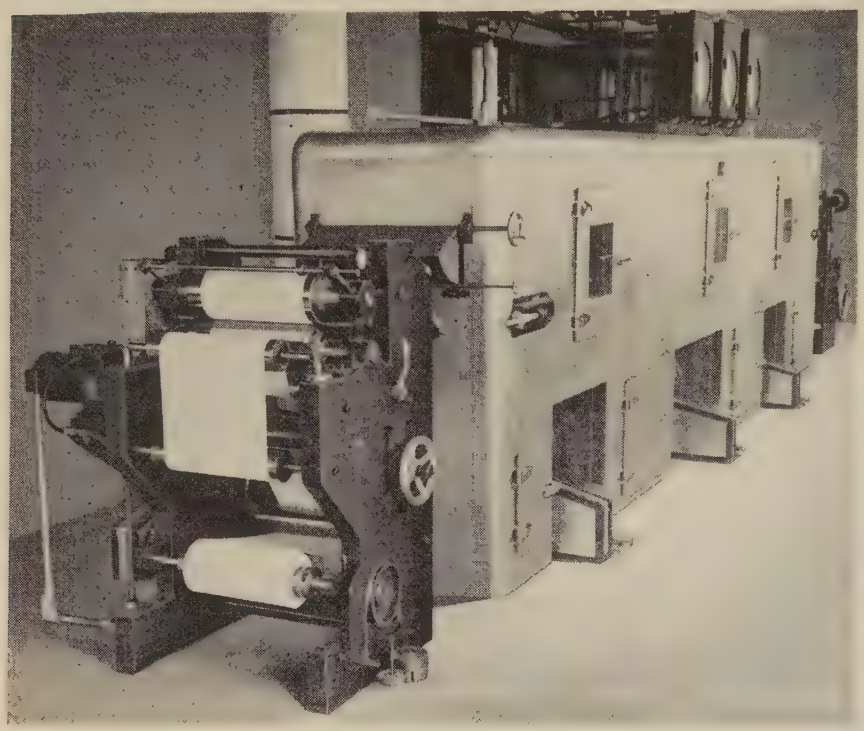

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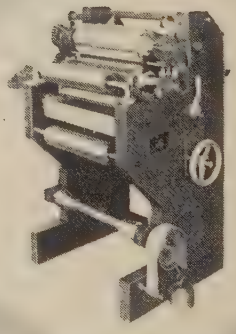

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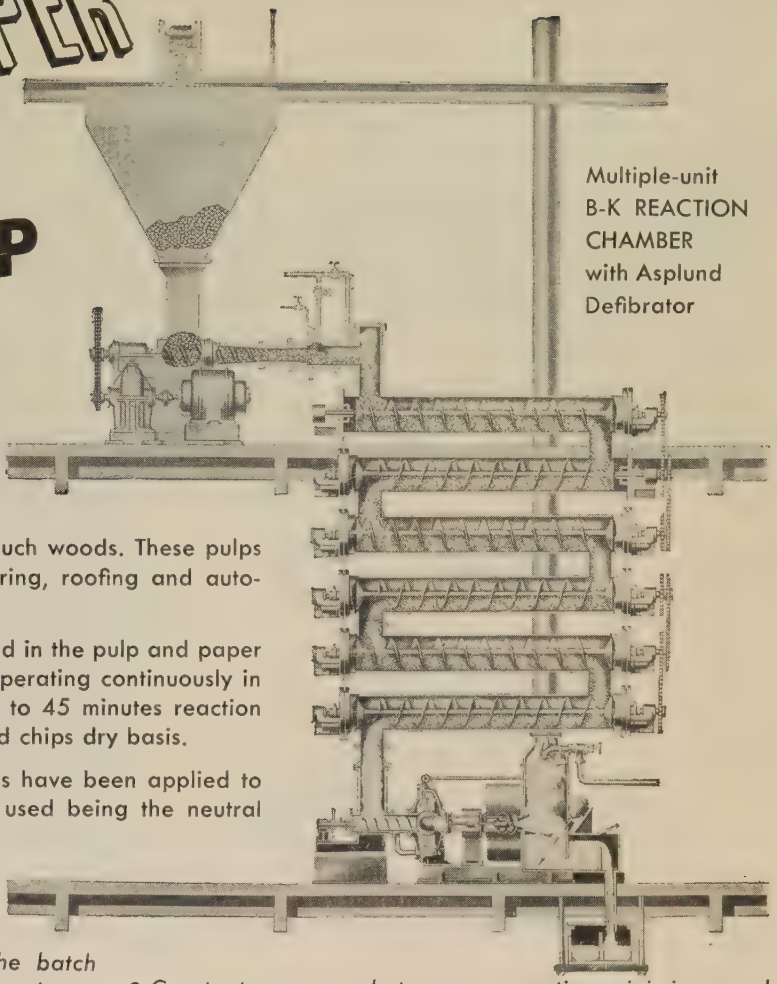

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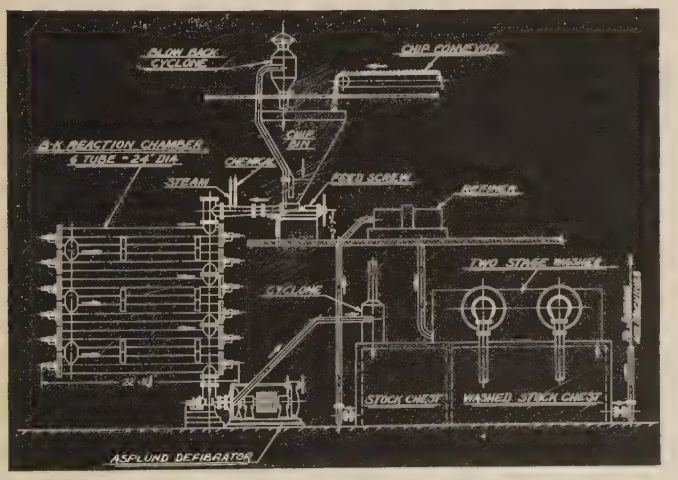
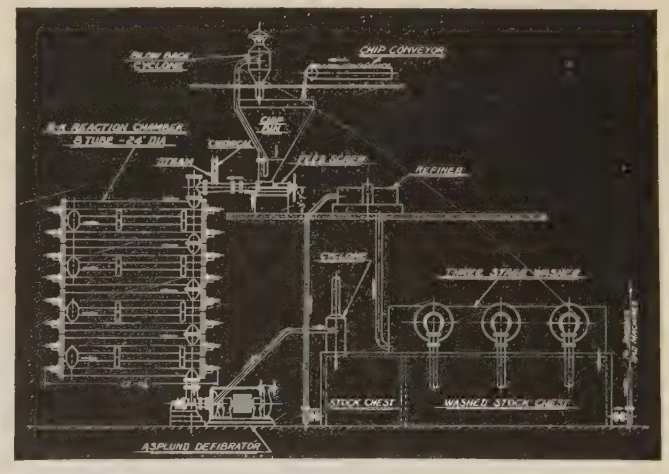


Flow drawing of the CHEMIPULPER with auxiliary equipment for producing semi-chemical pulps for Corrugating Board.



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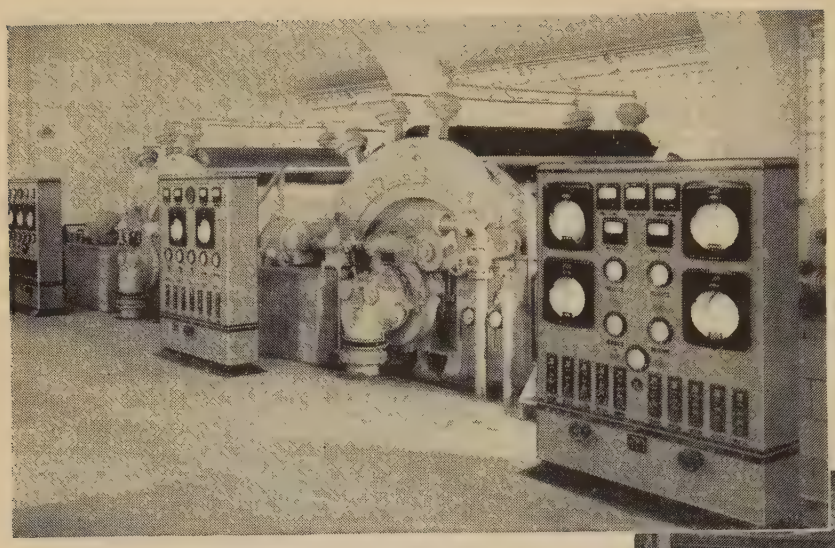

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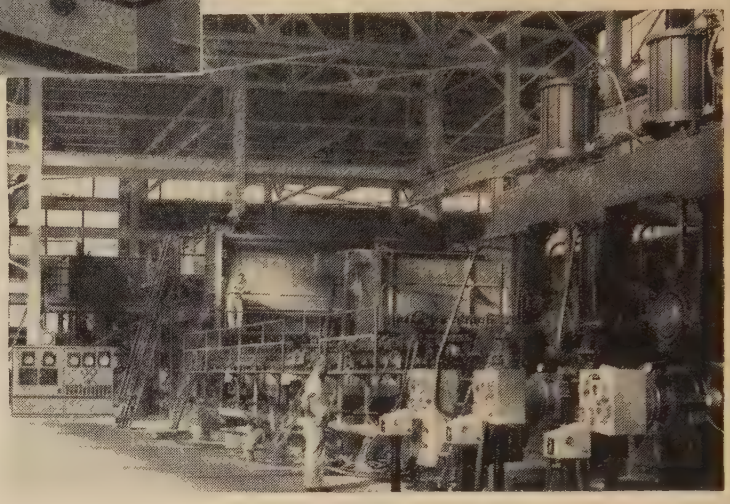

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Retention of Wet-Strength Additives in Paper

I. J. GRUNTFEST

The design and application of urea-formaldehyde resins for the manufacture of wet-strength paper is discussed in such a way as to emphasize the similarities of this process with those of sizing, filling, and dyeing of paper with wet-end additives. In particular, the importance of the ion-exchange capacity of the various pulps and the ionic character of the resins is considered.

SOME months ago, in connection with the development of urea-formaldehyde resins for producing wet strength in paper, Britt (*1*) stated that chemists are now able to "tailor make" organic molecules to accomplish definite objectives in the improvement of paper.

The object of this paper is to give some examples of tailor-made molecules, which are now used for improving paper, and to point out that the obstacles to further development are not the lack of resourcefulness of the synthetic chemists, but rather the complexity of the problem of paper technology which makes it difficult to formulate the requirements for paper reagents in specific chemical and physical terms.

The complexity of formulating requirements is illustrated by one of the first lessons learned by the papermaker: namely, that a process which works well in the laboratory or in one mill may fail quite badly in another mill even though the operating conditions seem to be identical. The existence of this situation highlights the challenge which confronts paper chemists today.

Because urea-formaldehyde wet-strength resins are completely synthetic materials whose properties, within wide limits, can be completely controlled by the organic chemist, they are a good example of tailor-made molecules for improving paper. In connection with this tailoring job attention will be focused on the question of the retention of the resin in the sheet rather than rambling over the whole field of wet-strength resins. The points to be dealt with are: (1) the similarities among retention problems whether they arise in connection with sizing, filling, coloring, or wet strength; (2) possible explanation of the diversity of the performance data obtained with urea-formaldehyde wet-strength resins by different American and European investigators; (3) some comparison of the retention characteristics of melamine-formaldehyde and urea-formaldehyde wet-strength resins.

While it is quite obvious that problems of the retention of size, color, or filling have much in common, most authors have been particularly concerned with one or the other of them so that the generality of the problems has not received much emphasis.

The first object here, therefore, is to review some of the ideas about retention that have arisen in different connections and to show how principles derived from studies in one field may be used in another.

Rosin size was probably the first reagent which was used to any extent in the wet end of the machine where retention was an important factor, Wieger is cited (*2*) as having given a list of different pulps arranged in order of the difficulties encountered in sizing them. Wilson (*3*) has been one of the most articulate exponents of the idea that the anionic character of the pulp is a most important factor in determining its response to sizing treatments. Price (*4*) has shown how small amounts of alkali in the water supply can cause difficulties with sizing.

The consensus among these authors and others is that the retention of rosin is due to a complicated interaction of the anionic pulp colloid, the anionic rosin colloid, and the cationic materials derived from alum.

Study of the dyeing and coloring of paper also has a long history. The general importance of the anionic properties of the pulp colloid is shown by the fact that basic dyes, which are cationic colloids, are well retained and retention of anionic or acid dyes requires the use of a cationic mordant-like alum. One of the most noteworthy papers on the subject of the anionic properties of various pulps is a study of the mechanism of dyeing reported by Sigvardt (*5*). Sigvardt points out that the anionic character of different pulps may be contributed by different functional groups. For example unbleached sulphite contains substantial amounts of sulphonated lignin. Bleached sulphites on the other hand are anionic because of the presence of carboxyl groups associated with the cellulose.

From the point of view of the general problem of retention this is a very important difference because while the sulfonate groups are anionic over the whole practical range of pH, the carboxyls are anionic at higher pH values only. At pH values near 4, much of their anionic character may be lost.

Even the retention of fillers and pigments appears to depend on the same electro-colloidal properties of the pulp as does the retention of resin and dye. This was pointed out by Haslam and Steele (*6*).

Study of the retention of wet-strength resins has, of course, a much shorter history. There is little or no disagreement about the general mechanism of the retention of the strongly cationic melamine-formaldehyde resins which are used in this application.

In contrast to the melamine-formaldehyde resins the electrical character of the urea formaldehyde can be adjusted by the organic chemist over a very wide range by the control of reaction conditions and use of various amounts of selected co-reactants. The definition of a material simply as a urea-formaldehyde resin is therefore incomplete. The precise cause of the retention difficulties reported by Steenberg (*7*) and Bursztyn (*8*) obviously cannot be given since the preparation of the urea-formaldehyde resins that were used were not described in sufficient detail.

The behavior of an anionic urea-formaldehyde resin (Uformite 467) was described by Myers and Morin (*9*). These authors showed that alum is required to obtain

I. J. GRUNTFEST, Rohm & Haas Co., Philadelphia, Pa.

good performance with these resins just as in the application of rosin. It has also been found that the treatment of some pulps with this resin is much more difficult than others and that these variations parallel those observed in the application of rosin size. The findings of Sigvardt cited above appear to be extremely relevant in connection with both of these retention problems. The fact that unbleached sulphite pulp can easily be sized with rosin and responds well to treatment with anionic urea-formaldehyde resins, whereas the bleached pulps often give difficulty suggests that the problems occur when the anionic character of the pulp is low and when it is due to the presence of carboxyl groups.

The plausibility of this suggestion is enhanced because of the properties of alum which is used as a mordant. The cation properties of the products of alum hydrolysis are extremely sensitive to pH in the range above 4. It is also precisely in this range the carboxyl group begins to lose its anionic property.

The difficulties in sizing and applying anionic urea-formaldehyde resins to bleached pulps can sometimes be overcome by careful attention to operating conditions but in other situations it is necessary to use cationic varieties of resin.

The above remarks which combine the contributions of Price (*4*) and Sigvardt (*5*) among others may be clarified by examination of Fig. 1 where the approximate pH ranges in which the various materials exhibit anionic or cationic character are indicated. The pH region in which both the pulp containing carboxyl groups is sufficiently anionic and the alum is sufficiently cationic to produce effective coflocculation of anionic reagents with the pulp is seen to be quite narrow. Staying within this range requires very close attention.

Notice that the delicacy of the problem of controlling operating conditions is eliminated when an appropriately cationic urea-formaldehyde resin is used since materials of this type can be made which are cationic over the entire practical range.

While the cationic urea-formaldehyde resins may be easier to apply, the lower cost of the presently available anionic type makes it worth while to determine in general whether adequate performance can be achieved with them.

Another matter which has relevance to the retention of urea-formaldehyde resins for wet strength is the caution that the very same cationic property that can aid the retention can sometimes hinder it. This will

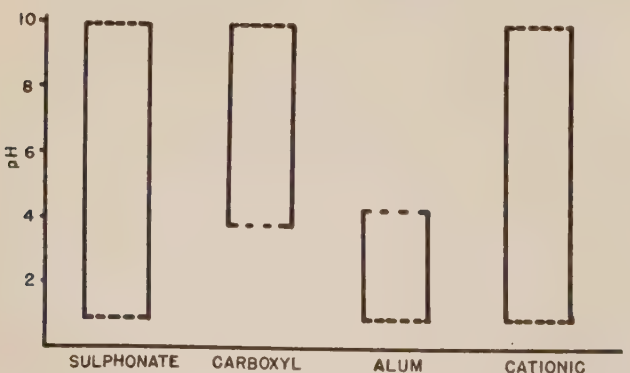

Fig. 1. Approximate ranges of ionic character for paper reagents

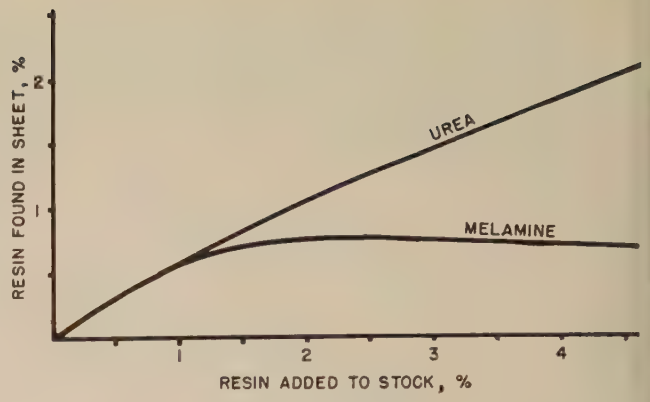

Fig. 2. Retention of cationic resins

happen if the pulp is only slightly anionic and the resin strongly cationic so that the charge of the pulp may be reversed when only a small amount of resin is absorbed and any excess will be wasted. With the urea resins the charge density can be controlled so that this situation may be avoided.

Figure 2 illustrates how excess cationic character can give trouble. Here is a comparison of the retention of a cationic urea resin with that of a melamine formaldehyde resin which produces a strongly cationic colloid.

It may be seen that saturation effects set in when about 2% of the strongly cationic melamine resin is applied. No saturation is observed even when 10% of the cationic urea is applied.

A final item in connection with the tailor making of urea wet-strength resins represents a digression from the retention problem. One of the urea resins which is commercially available has been found to have the special property of conferring high absorbency to the finished sheet. This is, of course, important in the manufacture of wet-strength toweling.

In summary, combining the ideas of Price, Wilson, and others derived from work on rosin sizing with those derived from dyeing experiments by Sigvardt and general notions about the properties of alum some generalizations can be deduced which are useful for the design and application of other wet-end additives, in particular urea-formaldehyde wet-strength resins.

The brief remarks about the wide range of properties which can be conferred on urea formaldehyde resins by organic chemists show the necessity for specifying the nature of the resin used in experiments which are described in the literature.

Overcoming the saturation effects which are shown to occur for wet-end additives which are too strongly cationic, and the development of resins which produce wet-strength papers with good absorbency are examples of the results achieved by tailor-made reagents for paper.

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Received Nov. 21, 1945. Presented at a meeting of the Maine-New Hampshire Section of TAPPI, Portsmouth, N. H., June 17, 1949.

The Mechanism of the Softening of Paper by Glycerin

WILLIAM H. McPHERSON, JR.

The effect of glycerin in softening paper does not appear to be the result of humectant properties. At any relative humidity, the amount of water held by glycerin-treated sheets is less than the amount which would be held by the same amount of glycerin and cellulose separately. At low relative humidities, the amount of water held by glycerin-treated sheets is less than that held by untreated sheets alone. Glycerin does not soften paper solely because of its lubricating action. At low-glycerin contents (up to 10%), the internal friction of paper sheets was found to be higher than that of untreated sheets. With high-glycerin contents, the internal friction of the paper was decreased. In this region, fiber lubrication may play a significant role. Tensile strength measurements showed that the sheet becomes weakened with increasing glycerin content. The relationship between the tensile strength and the softness, as measured by flexural rigidity, was approximately linear. The observed softening is attributed to a corresponding weakening of the fiber bonding in the sheet. Both water and glycerin are effective softening agents. As an approximation, two molecules of water are equivalent to one molecule of glycerin in increasing softness as measured by flexural rigidity. The concept of the mechanism of paper softening, as developed in this work, has shifted the emphasis from the hygroscopic and lubricating properties of the softener to the more basic aspects of sheet structure and to the relationship of softness and fiber bonding.

In the manufacture of paper it is often necessary to produce a sheet which is soft and flexible in order to satisfy use requirements. Sometimes the degree of softness required can be achieved by proper selection of pulps and methods of their processing into paper. Quite often additional softening is required, as in the case of some glassine papers, coated and impregnated papers, and a number of specialty papers where a soft clothlike paper is desired by the trade. This softening can be obtained only through incorporation of suitable agents in the paper.

The terminology in this field has not been wholly consistent or definitive. The words softener, plasticizer, and humectant have been used to describe materials added to paper to render it softer and more flexible, particularly at low relative humidities. Some confusion also has arisen because of the lack of means for adequate instrumental evaluation of the desired sheet properties, and the description of sheet characteristics too often has been based on purely subjective observations.

For the present purpose, the word softener is considered to define the properties under consideration more accurately than the term plasticizer, and it will be used in the discussion which follows. The term humectant will be reserved for those materials which are added to a product solely for the purpose of increasing its equilibrium moisture content, particularly at low relative humidities.

William H. McPherson, Member TAPPI; Graduate Student, The Institute of Paper Chemistry, Appleton, Wis. Present address, Research Department, International Paper Co., Glens Falls, N. Y.

The mechanism by which softeners are effective in altering the character of a paper sheet has not yet been satisfactorily or completely explained. Pike (*1*) and Connor and Nadelmann (*2*) believed that softeners are effective through their lubricating action on the fibers. This concept implies that the extent of fiber-to-fiber bonding in the softened sheet must be relatively small.

If the fiber-to-fiber bonds are weakened by the presence of a softener, the presence of these weakened bonds then becomes a possible explanation of the action of sheet softeners, in a fashion somewhat similar to that presented by Ott (*3*) as a mechanism for the modification of cellulose plastics.

The action of softeners on paper often has been tacitly assumed to be a result of their hygroscopic properties (*17, 18*). It has been implied that they hold moisture in a sheet of paper at low relative humidities and, thus, that they keep the paper soft through the action of the water. This accounts, at least in part, for the common confusion of the terms softener and humectant. It is accidental, perhaps, that many paper softeners are of a hygroscopic nature, and it has not been shown heretofore that there is any generic connection between the two types of action in a paper sheet.

Although earlier views were that the softening effect of hygroscopic substances was primarily the result of holding water in the sheet, the trend in recent years has been to recognize the inherent softening character of these substances, independently of the contribution of the bound water (*1, 19*). The recognition that two independent effects may exist when hygroscopic softeners are present represents a distinct advance, and this viewpoint has been pursued further in the present work.

The effect of softeners on fiber flexibility and the relationship of fiber flexibility to the softness of a sheet made from the fibers have not been adequately examined. Work of this nature has been carried out as a sequel to the present investigation, and it will be reported upon in a forthcoming publication.

The present work was undertaken with the hope of explaining more fully the way in which a paper softener is effective. Glycerin was selected for the study because of its wide use in the industry for producing softness in paper. The study was limited to papers in which the degree of beating of the pulp was only moderate and papers of the type represented by greaseproof and glassine grades were not investigated. This limited scope also precluded any interpretation of the effect of nonhygroscopic substances in softening paper.

THE WATER CONTENT OF GLYCERIN-TREATED SHEETS

In order to study the possible contribution of hygroscopically held water to paper softness, the water content of glycerin-treated cellulose and paper sheets was investigated over a wide range of relative humidities. To avoid the presence of large quantities of noncellu-

Table I. Moisture Content of Glycerin-Treated Alpha Sheets at Various Relative Humidities

Glycerin content, %[a]	Glycerin, mg.[b]	Relative humidity, % / Moisture content of dry glycerin-free paper, mg./g.[c,d]								
		32.8	11.1	11.1	32.8	53.2	64.6	75.4	64.6	53.2
		f	f	e	e	e	e	e	f	f
0	0	51.8	28.4	25.6	47.6	67.6	82.5	101.7	89.4	75.6
2.95	32.4	46.9	22.4	21.7	44.1	66.6	85.5	109.8	92.5	74.6
9.22	109.3	46.1	18.2	16.0	44.2	76.7	106.7	147.6	110.5	81.8
21.5	306	59.8	18.9	18.0	57.6	113.9	170.3	255	169.6	115
52.9	1530	185.2	49.8	47.2	177.5	389	595	933	..	..

[a] Based on total sheet weight at 50% R. H.
[b] Milligrams glycerin per gram dry glycerin-free fiber.
[c] Average of two determinations.
[d] Samples started from 50% R. H.
[e] Approached from lower relative humidity—adsorption point.
[f] Approached from higher relative humidity—desorption point.

losic materials, which might interfere in an interpretation of the results, the studies were limited to cotton linters and to paper handsheets made from a softwood alpha pulp.

The cotton linters were purified linters obtained from the Hercules Powder Co. They contained 98.3% alpha-cellulose and 0.13% ash, and had a cuprammonium viscosity of 124 cp. by the TAPPI method. They were further purified by extraction with benzene in a Soxhlet extractor for 4 hours and by two successive 1-hour extractions with boiling water. The purified linters were sucked dry on a Büchner funnel and allowed to dry in a room conditioned at 50% relative humidity and 73°F.

The alpha pulp sheets were prepared from a commercial softwood alpha pulp, which was beaten according to TAPPI Standard T 200 m-45 to a Schopper-Riegler freeness of 630 ml. The pulp was formed into handsheets which were pressed, dried for 2 minutes on a steam-heated revolving drier, and conditioned in the same way as the cotton linters.

The linters and alpha pulp sheets were prepared in lots containing varying quantities of glycerin by soaking in water-glycerin baths of concentrations which were shown, by trial, to be suitable. It was found that the glycerin content after treatment of both the sheets and the linters was about 80% of that calculated from the glycerin content of the treating bath and the gain in weight of the sheets during the treatment.

After treating in the appropriate glycerin bath for 4 hours, the linter samples were freed of excess solution by suction on a Büchner funnel and conditioned at 53% relative humidity and 73°F. The alpha sheets were soaked in the glycerin bath for 15 minutes, placed for 1 hour between blotters soaked in the same glycerin solution, and the sheets and blotters pressed together at 30 p.s.i. The sheets were then conditioned in the same way as the linters.

The glycerin content of the treated materials was determined by the periodate oxidation method originally described by Malaprade (*21*). A portion of the linters or paper samples containing 20 to 30 mg. of glycerin was extracted with 25 ml. of boiling water for 45 minutes. The solution was filtered, the fibers were washed with several small portions of water, and the combined filtrate and washings were used for the analysis. Blanks were determined on the materials not treated with glycerin and the glycerin analyses were properly corrected for the corresponding blank.

The moisture contents of the glycerin-treated materials were determined at various relative humidities by the method of Wink (*4*). This method is based upon weighing the specimen under the desired conditions of relative humidity and, finally, determining its dry weight over phosphoric anhydride. The specimens (about 1 gram each) were placed in Petri dishes which were suspended individually in small closed chambers in which the relative humidity was maintained at the desired level by the presence of saturated salt solutions.

The hysteresis in the moisture content of cellulose required that definite cycles of adsorption and desorption be used in this study. The alpha sheets were subjected to decreasing relative humidities to the dry condition; they were then allowed to absorb moisture, through chosen intermediate points, to a final condition of 75.4% relative humidity and, finally, they were returned to 53% relative humidity. Essentially the same cycle was used for the cotton linters, except that the maximum humidity was 92.8%.

The specimens were weighed at intervals at each relative humidity condition until constant weight was attained. From the weights thus obtained, and from the dry weight of the specimens, the moisture content was calculated. At relative humidities of 53.2% or less, the specimens could be weighed accurately to about 0.2 mg. At higher relative humidities, or with specimens containing large quantities of glycerin, the specimens could not be weighed reproducibly to better than 1 to 2 mg. because small fluctuations in temperature prevented attainment of true equilibrium conditions and the resulting error in weight was relatively large.

At low relative humidities, constant weight was obtained in about 100 hours. At higher relative humidities and for samples containing large quantities of glycerin, periods up to 300 hours were required to obtain constant weight.

The volatility of glycerin cannot be disregarded, despite the high boiling point of the compound. However, it was found that the loss of glycerin was very small after cycling of the materials through the various relative humidity conditions, and it is believed that any error from this source is negligible.

The moisture content data for the glycerin-treated alpha sheets are given in Table I. The results are expressed as percentages on the basis of the glycerin-free, moisture-free fibers. The corresponding data for the glycerin-treated cotton linters are given in Table II.

If the glycerin and cellulose in these materials exhibit their respective hygroscopicities in a wholly independent manner, it would be expected that the total water content could be found as the sum of the corresponding water content of each constituent at equilibrium. The moisture content of glycerin alone was taken from data given in International Critical Tables (*7*). The water content of the cellulose fibers alone was determined from observations made with no glycerin present.

It was found that the total water content at all relative humidities was less than that which would be de-

Table II. Moisture Content of Glycerin-Treated Cotton Linters at Various Relative Humidities

Glycerin content, %[a]	Glycerin, mg.[b]	Relative humidity, %								
		32.8	11.1	32.8	53.2	64.6	75.4	92.8	64.6	53.2
		Moisture content of dry glycerin-free linters, mg./g.[c,d]								
		f	f	e	e	e	e	e	f	f
0	0	47.8	24.3	41.6	59.8	72.1	87.8	154	84.1	69.5
0.62	6.6	47.4	23.1	40.9	59.7	73.6	90.8	165	86.1	70.2
1.06	11.3	46.5	22.4	40.3	60.2	73.4	91.6	171	85.8	69.0
2.53	27.5	43.8	19.4	38.0	59.1	74.6	96.6	198	85.4	67.4
6.35	72.0	42.7	17.2	37.9	63.6	84.6	115	297	91.0	68.3
11.72	142.9	45.6	16.0	41.6	78.1	112.2	164	491	114	79.1
13.9	177.1	54.8	16.2	51.4	108.2	160.6	252	967	164	107.3
22.2	323	69.2	19.6	65.5	140.7	213.3	336	1340	218	141.1

[a] Based on total sheet weight at 50% R. H.
[b] Milligrams glycerin per gram glycerin-free fiber.
[c] Average of three determinations.
[d] Samples started from 50% R. H.
[e] Approached from lower relative humidity—adsorption point.
[f] Approached from higher relative humidity—desorption point.

duced from the equilibrium data on the separate substances. The relationship for the alpha sheets is shown in detail in Fig. 1, in which it is seen that the observed deficiency in total water increases regularly with increase in glycerin content and with increasing relative humidity to which the materials were subjected. The corresponding curves for the cotton linters, although not shown, were found to be of similar nature. Relationships of this kind have been reported by Pike (*1*) and Hardenberg (*20*) as the results of tests of limited scope, in which it was found that the moisture content of papers treated with glycerin decreases at very low relative humidities.

The discrepancy between the calculated and observed moisture contents indicates that the hygroscopicity of the glycerin or of the cellulose or both is modified in some way in the cellulose-glycerin-water system. These observations may be explained in a qualitative way by the statement that glycerin is adsorbed by the cellulose. The polyhydric nature of both cellulose and glycerin might reasonably be expected to produce effects of the kind observed because of the interactions of the hydroxyl groups.

The increasing discrepancy with increasing glycerin content suggests that more glycerin is adsorbed by the cellulose as the glycerin content of the system is increased. The curves tend to level off with increasing glycerin concentration, probably because the cellulose is becoming saturated with glycerin.

Evidence for the adsorption of monohydric alcohols and of glycols by cellulose is found in swelling (*22*, *23*) and in heat of wetting data (*24*, *25*). Similar data for glycerin have not been presented, but it would be expected that its behavior would parallel that of the simpler hydroxyl compounds.

The deficiency of water held by the glycerin-treated sheets is so great that the total moisture contents of sheets containing up to 9% glycerin are actually less than those of untreated sheets at relative humidities below 32.8%. Similar results were obtained for the cotton linters; at 32.8% relative humidity, the linters containing up to 11.7% glycerin had lower moisture contents than untreated linters.

The data of Tables I and II show that the hysteresis in moisture content of glycerin-treated cellulose and sheets decreases with increasing glycerin content. The hysteresis in the moisture content of cellulose is explained by Urquhart and Williams (*5*) as the result of swelling and collapse of the cellulose structure in the adsorption and desorption cycle. In the original wet condition the free hydroxyl groups of cellulose are practically all satisfied by water. When the cellulose is dried, the hydroxyl groups are freed and, in the shrinking of the cellulose structures, adjacent pairs are drawn together so as to satisfy secondary valence forces. In the adsorption cycle, some of these hydroxyl groups are not available and a decreased adsorption is observed. The action of glycerin in effecting a decrease in hysteresis may be pictured as one of satisfying a portion of the hydroxyl groups so that they do not become irreversibly bonded upon drying. The mechanism would be effectively the same as that of glycerin adsorption by the cellulose. Shutt and Mack (*6*) reached essentially the same conclusion in their study of glycerin-treated cellophane.

The consideration of these data leaves no doubt that the softening effect of glycerin at low relative humidities, the region in which supplementary softening agents are of most interest, is not attributable to a humectant action or to enhanced water-holding capacity. This statement does not imply that there is no softening action by the glycerin itself, but it seems clear that this effect must be dissociated from any humectant properties in this region of low humidities.

THE INTERNAL FRICTION OF GLYCERIN-TREATED SHEETS

The contribution of fiber slippage, or of a "lubrication" effect of the fibers in a sheet, was studied by measuring the internal friction of prepared paper sheets. The internal friction is only an indirect measure of possible fiber lubrication, but the data were expected to be of value in assessing possible reasons for softening action.

In order to explain how fiber lubrication can be measured by this method, the sheet of paper can be thought of as a beam. When the beam is made to vibrate, it will continue to do so until the energy is transformed through friction into heat. This friction is ascribable to the viscosity of the medium in which vibration occurs and to internal friction in the members which are deformed. In the case of paper, the internal friction is due to friction between fibers and within fibers. The internal friction then would be decreased by any lubricating action wherein lubricant molecules decreased the force of attraction between fiber surfaces or micelles in the fiber.

It has been shown by Van den Akker (*8*) that internal friction in paper can be measured by the use of a torsion pendulum of the type shown in Fig. 2. The rod A carries two masses whose distance from the center may be varied. A clamp C is rigidly connected to the rod and the assembly is hung on a fine wire having a small torsion constant. The specimen strip is clamped at one end

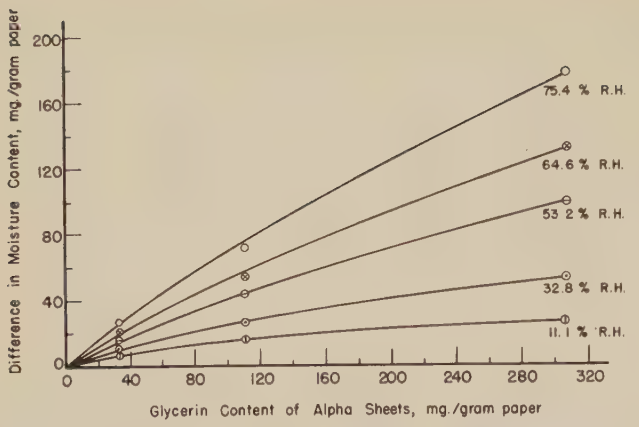

Fig. 1. Difference between observed and calculated moisture contents of glycerin-treated alpha sheets at various relative humidities

and the other end of the strip is cemented to a pin which can move in the arc of a circle as well as rotate on its axis. The specimen thus is allowed lateral motion but no vertical motion in flexure. To operate, the pendulum is given a small displacement, is released, and its period T is measured with a stop watch. The initial and final displacements after n swings are observed. In order to obtain greater accuracy, a beam of light is directed on the mirror M on clamp C which rotates. The reflected light falls on a circular scale about 10 inches from the center of rotation and displacement readings are observed on the scale. The equation for the determination of the internal friction coefficient is given by:

$$C = (18.4\ LI/bw^3)[\log_{10}(\theta_0/\theta_n)/nT - \log_{10}(\theta_0/\theta_n)_0/n_0T_0]$$

where

C is the internal friction coefficient in poises
I is the moment of inertia of the torsion pendulum in grams per square centimeter
L is the length of the sample in centimeters
b is the width of the sample in centimeters
w is the caliper of the sample in centimeters
θ_0 is the initial displacement in degrees (or relative units)
θ_n is the final displacement in degrees (or relative units)
n is the number of complete oscillations
T is the period of oscillation
$(\theta_0)_0$, $(\theta_n)_0$, n_0, T_0 are values with no sample in place.

Alpha pulp sheets containing up to 42% glycerin were prepared for the internal friction measurements. The sheets were made from alpha pulp that had been beaten in the Valley laboratory beater for 36 minutes with 6500 grams on the bedplate to give a pulp of 630 ml. Schopper-Riegler freeness. Sheets of an airdry weight of 2.5 grams and about 8.5 inches square were made on the Noble and Wood sheet mold. The sheets were couched off on blotters, placed between dry blotters, and pressed for 2 minutes at 90 p.s.i. on the Williams press. The sheets were then removed and dried on the Noble and Wood revolving drier. The dry sheets were conditioned at 50% R. H. and 73°F. To give the sheets a desired glycerin content, they were dipped into glycerin baths of proper concentrations and then allowed to soak between saturated blotters for an hour. Then each blotter with a sheet adhering to it was lightly pressed at 30 p.s.i. for 1 minute in the Williams press. This method of soaking and pressing was found to give sheets of uniform glycerin content. After pressing, the sheets were removed from the blotters, dried for 2 minutes on the Noble and Wood sheet drier, and subsequently conditioned at 50% R. H. and 73°F.

The internal friction of glycerin-treated sheets was measured at several relative humidities in order to determine the effect of moisture on this property. Water itself is an effective softener and, therefore, it is of value to determine how it affects fiber lubrication as measured by internal friction. A cabinet was made of sheet metal for providing constant relative humidity conditions over a wide humidity range. The relative humidity was controlled in the cabinet by introducing air through washing bottles containing saturated salt solutions selected to give the proper equilibrium relative humidities. The relative humidity was determined in the cabinet with an electric hygrometer as described by Van den Akker (*9*). At 6.5% R. H., where the use of the hygrometer has not been evaluated, a weighing method was used to determine the relative humidity. Sheets of alpha pulp were weighed and the relative humidity was calculated from their moisture content and the moisture equilibrium data.

The internal friction data for glycerin-treated alpha sheets are plotted in Fig. 3. At all relative humidities, the internal friction was found to increase at first and then to decrease with increasing glycerin content. If only a lubricating action were involved, a direct decrease in internal friction would be expected with increasing glycerin content. It will be shown later (Fig. 5) that the softness of the sheets, as measured by flexural rigidity, increases directly with increasing glycerin content. Therefore, glycerin must not soften by virtue of its lubricating action below 10% glycerin content. At glycerin concentrations above 10%, the internal friction decreases in a fashion similar to the decrease in flexural rigidity as seen in Fig. 5. Probably, at higher glycerin contents, lubrication is directly related to the softening of paper.

THE RELATION OF SOFTNESS AND FIBER BONDING

The decrease in strength of bonding has been found to explain plasticizing action in cellulose derivative plastics. In their patent for absorbent clothlike paper,

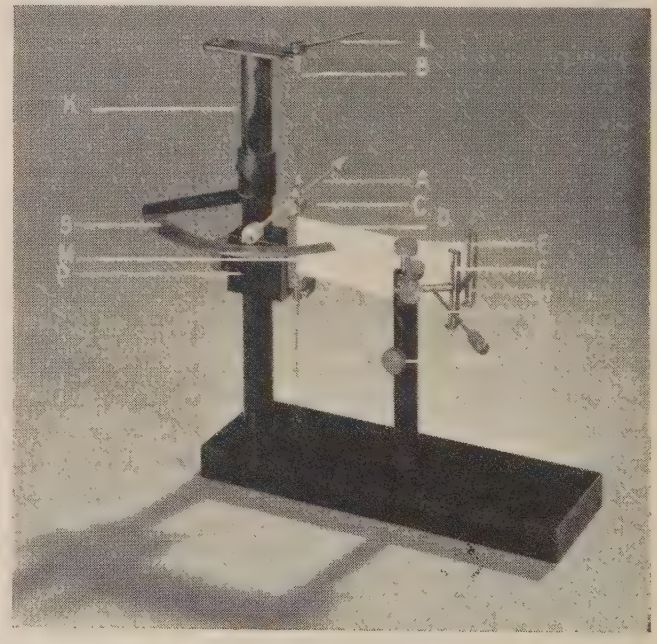

Fig. 2. Torsion pendulum

Richter and Schur (*10*) mentioned that glycerin-treated sheets had lower strength than the untreated. A decrease in either individual fiber strength or bonding strength between fibers would explain a decrease in over-all sheet strength.

In order to determine whether glycerin weakened fiber bonding in paper, it was first necessary to ascertain the effect of glycerin on the tensile strength of individual fibers. For this experiment, individual cotton hairs from cotton linters were chosen for tensile measurements. Fifty cotton hairs of about the same length were selected from a sample of 10 grams of linters of 7.2% glycerin content. Another 50 hairs of about the same length were selected from 10 grams of untreated linters. Both the treated and untreated fibers for the tensile tests were divided into two groups of 25 each so that the precision of the measurements could be checked. The tensile test of each fiber was determined with the Saxl single fiber tester.

The tensile strengths of glycerin-treated and untreated cotton hairs are given in Table III. The data indicate that the tensile strength of individual cotton fibers containing 7.2% glycerin is not decreased by glycerin. Mann (*11*) has determined the tensile strengths of cotton hairs at several relative humidities and found that moisture actually increased their tensile strength slightly. Evidently, water and glycerin have a similar effect on the tensile strength of cotton fibers.

Recently the work of Klauditz, Marschall, and Ginzel (*12*) has shown that the wet tensile strengths of wood pulp fibers are but 42% of their dry strengths. This loss of strength in wetting is contrary to the reported behavior of cotton fibers. Work at The Institute of Paper Chemistry (*13*) indicates that 100% rag papers

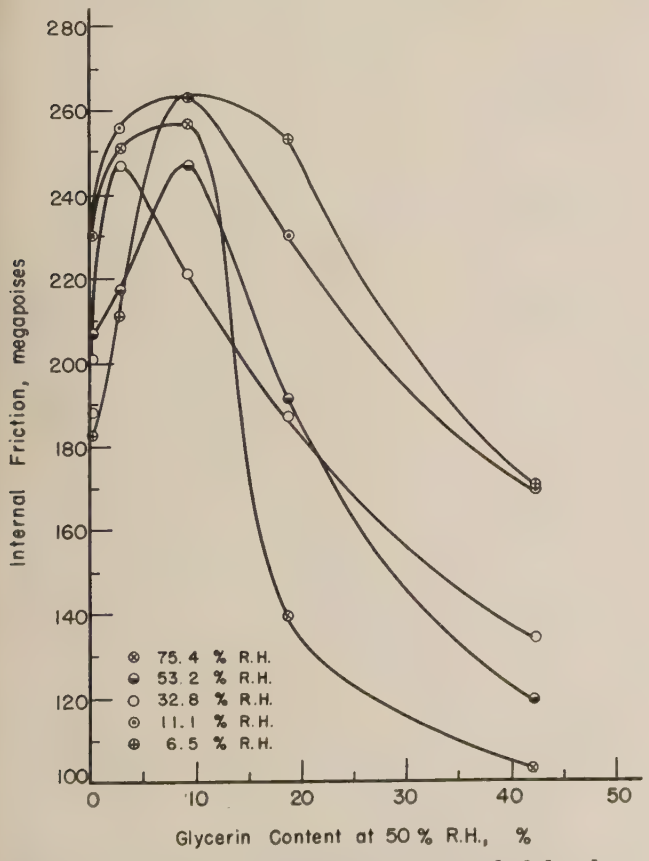

Fig. 3. Internal friction of glycerin-treated alpha sheets at various relative humidities

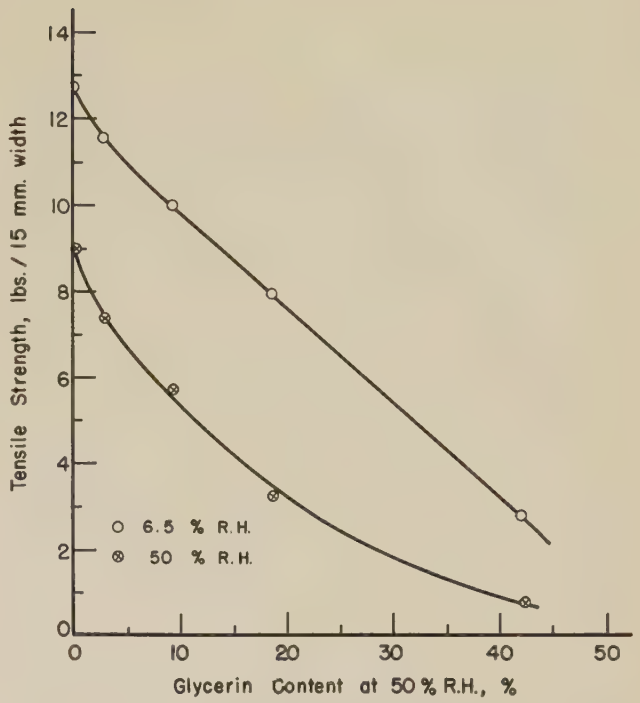

Fig. 4. Tensile strength of glycerin-treated alpha sheets at two relative humidities

show the same trend and relative magnitude of change in tensile strength with change in relative humidity, as do papers whose furnish is partly or wholly wood pulp. All are weaker at high than at low relative humidities. Because cotton fibers do not lose tensile strength at high relative humidities, the decrease in tensile strength of rag papers with increasing relative humidity cannot be due to weakening of the fibers but must be due to weakening of the fiber bonding. In the case of many wood pulp sheets the bonding in the sheets is so poor that little advantage is taken of the ultimate strength of individual fibers and the tensile strength of the sheets is determined principally by the fiber bonding, and fails to approach the ideal limiting value which would characterize a perfectly bonded sheet—i.e., a sheet in which failure involves fiber but no bond breakage. Hence, even though the tensile strengths of the individual wood pulp fibers may decrease to about 50% of their dry strengths when the relative humidity is increased to high values, the tensile strength of the sheet is still determined principally by the fiber bonding and the decrease in tensile strength with increasing relative humidity is, therefore, ascribed to weakening of the fiber bonds. On the basis of the observed similarity of the effect of water and glycerin on the tensile strength of cotton fibers, it is presumed that the two materials behave alike in any effect they may have on the strength of wood pulp fibers.

As a measure of fiber bonding, the normal tensile test is not wholly satisfactory for, according to Clark (*14*),

Table III. Tensile Strength of Cotton Linter Hairs at 50% R. H.

Glycerin content, %	*No. of tests*	*Average tensile, g.*	*Maximum tensile, g.*	*Minimum tensile, g.*	*Standard error*
0	25	5.7	8.0	3.0	0.26
0	25	5.9	10.0	3.0	0.32
7.2	25	6.0	11.0	3.0	0.39
7.2	25	6.0	10.0	4.0	0.34

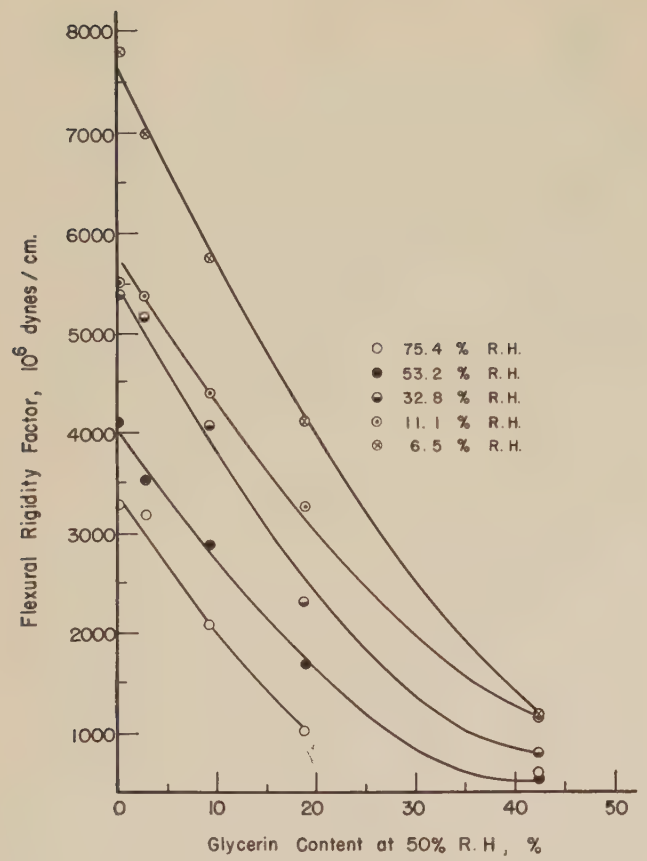

Fig. 5. Flexural rigidity of glycerin-treated alpha sheets at various relative humidities

it is influenced by factors other than fiber bonding. For instance, the length of the fibers is important because longer fibers may be woven into the sheet structure. A short fiber may be pulled out of a sheet more easily than a longer one, although both may have the same degree of adhesion. However, for a comparison of the bonding strength in sheets whose only difference is in softener content, the tensile test is of value.

The tensile strengths of glycerin-treated papers were determined at two relative humidities, 50 and 6.5%. The tests were made on specimens of the same alpha sheets as those used for the internal friction measurements. The Standard Schopper tensile tester was used at 50% R. H., but it was necessary to use the portable Schopper tensile tester at 6.5% R. H. The small tester was found to read about 11% low, but the values obtained with it were corrected for this calibration error. The tensile strengths of glycerin-treated alpha sheets at 50 and 6.5% R. H. are shown in Fig. 4.

It is evident that the tensile strength of alpha sheets is decreased by glycerin. Even at 6.5% R. H. where the moisture content of the glycerin-treated sheets is less than that of the untreated sheets, except for sheets containing 42% glycerin, the tensile strength of the sheets decreased with increasing glycerin content. It is seen from the tensile test data for untreated sheets that moisture also decreases sheet tensile strength. Therefore, it is concluded that glycerin and water decrease sheet strength mainly by weakening fiber bonding. It remains to be demonstrated that a weakening of fiber bonding results in increased softness of the sheet.

THE SOFTNESS OF GLYCERIN-TREATED SHEETS

Although no one method for measuring the softness of paper is accepted throughout the paper industry, the Clark softness test has been used to evaluate softness and has been accepted by the Technical Association of the Pulp and Paper Industry as a tentative method (T 451 m-45). The Institute of Paper Chemistry (*15*) found that Clark rigidity correlated well with flexural rigidity as determined by a research method involving a torsion pendulum. Subjective tests for softness of facial tissues, towel tissue, waxing glassine, and bread wrappers were found to correlate well with the mean of the machine direction and the cross-machine direction Clark softness values.

As a measure of softness of the alpha sheets, the flexural rigidity was determined by use of the torsion pendulum shown in Fig. 2. Van den Akker (*16*) has described the use of this instrument in measuring the flexural rigidity of paper and has shown that the flexural rigidity is expressed by the equation:

$$EI = (4^2 I' b/3)[(1/T)^2 - (1/T_0)^2]$$

where

EI is the flexural rigidity in dynes per square centimeter
I' is the dynamic moment of inertia of the pendulum in grams per square centimeters
b is the length of the sample between clamps in centimeters
T is the period of oscillation with the sample in place in seconds
T_0 is the period of oscillation in seconds of the pendulum with no sample

The flexural rigidity factor data are plotted in Fig. 5. The flexural rigidity was divided by the cube of the thickness of the sheets to place the results on a unit thickness basis. The quotient is called the flexural rigidity factor and the units become dynes per centimeter.

At all relative humidities, the flexural rigidity factor was less for the treated sheets. With increasing relative

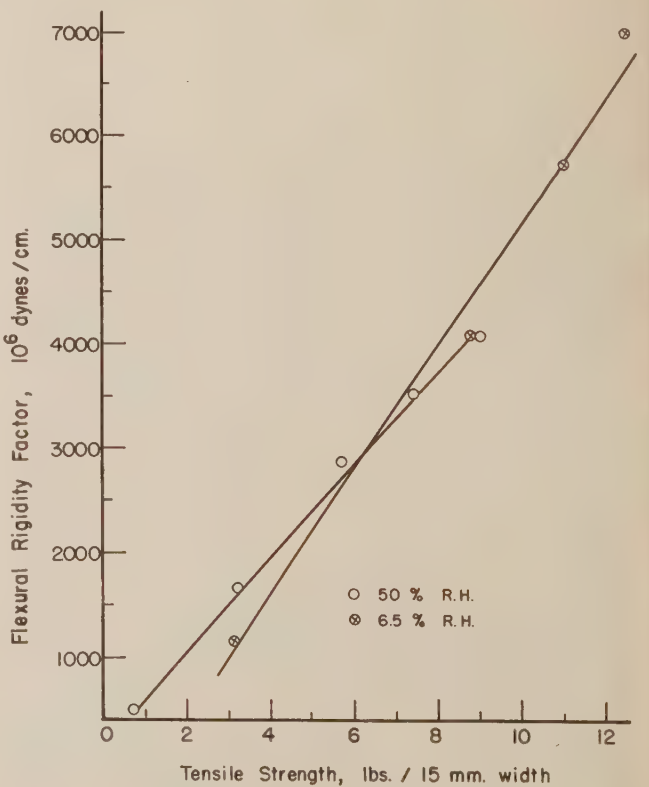

Fig. 6. Flexural rigidity vs. tensile strength of glycerin-treated sheets

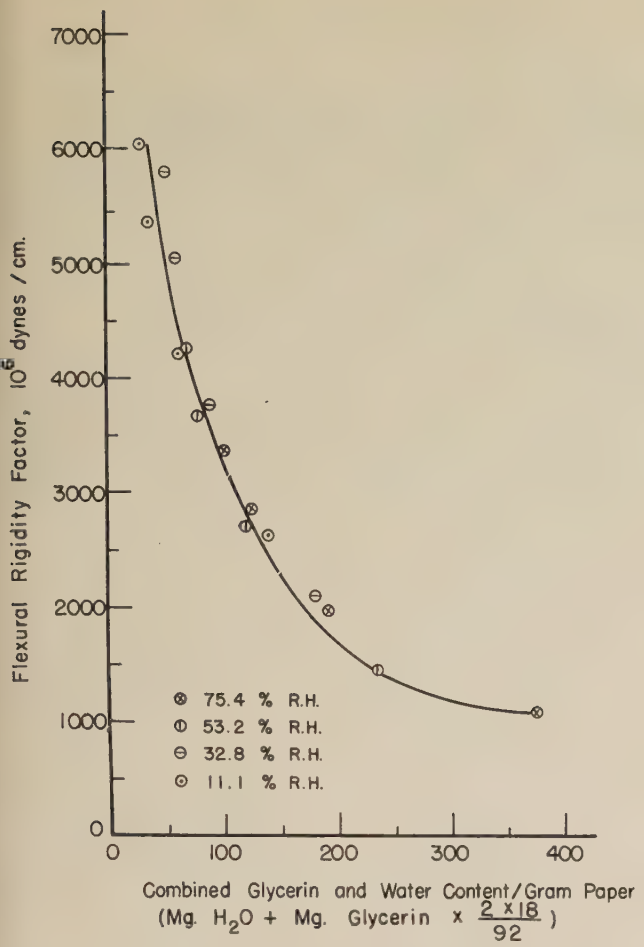

Fig. 7. Flexural rigidity as a function of combined glycerin and water contents in which one mole of glycerin is equivalent to two moles of water

humidity, the flexural rigidity factor was also found to decrease. Therefore, both water and glycerin are effective in reducing the flexural rigidity or increasing the softness of paper.

In order to show the relation between softness and the weakening of fiber bonding, the flexural rigidity factor was plotted against the tensile strength in Fig. 6. An approximately linear relation was found to hold at both 6.5 and 50% R. H. Even though the tensile test depends on the ultimate strength of fiber bonds, whereas the rigidity test depends on their strength under less drastic conditions, the observed relationship indicates that both properties are closely related to fiber bonding strength.

EQUIVALENCE OF WATER AND GLYCERIN IN SOFTENING

If the softening of paper is caused by the weakening of fiber bonds, it might be expected that glycerin and water would exhibit the same mechanism in softening and, therefore, both agents might be effective as softeners. Although water is an effective softening agent for paper, it cannot be used commercially because of its high vapor pressure at normal temperatures. The advantage of glycerin as a softening agent lies in its low vapor pressure—0.0025 mm. mercury at 50°C. In order to compare the relative effectiveness, the flexural rigidity factors of the glycerin-treated alpha sheets were plotted against moisture content plus the effective glycerin content. This was done on a weight basis with the assumption that one molecule of glycerin is equivalent to one, two, and three molecules of water. The best correlation was found for the case in which one molecule of glycerin was considered equivalent to two molecules of water. The plot is shown in Fig. 7. This relationship is not exact and is probably a statistical average. The fact that one curve can be used to relate the flexural rigidity factor and various combinations of glycerin and moisture strengthens the argument that glycerin and water act similarly in their softening mechanism.

The equivalence of two molecules of water to one of glycerin in effecting softness in paper seems to be reasonable on the basis of the configuration of the cellulose units. Because of the spatial configuration of hexose units in cellulose, it seems unlikely that all three hydroxyl groups of glycerin would be attracted to corresponding cellulosic hydroxyl groups. On the other hand, the cellulose surfaces must be very close together in order to have attractive forces holding the fibers together in a sheet of paper and thus it would seem improbable that, on the average, only one hydroxyl group would be attracted to the cellulose surface in such limited space. From such considerations there is some theoretical justification for the equivalence of one molecule of glycerin to two of water in softening paper.

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Some Terpene Carboxy Esters from Turpentine

Their Synthesis from Crude Sulphate Turpentine and Other Sources and Their Preliminary Evaluation as Plasticizers

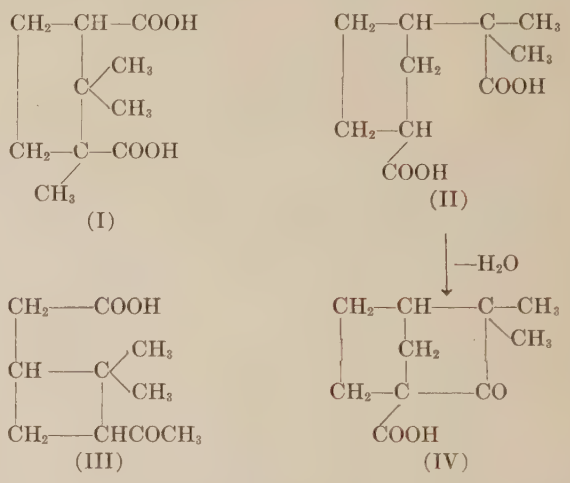
TORSTEN HASSELSTROM, CLIFFORD E. BALMER, NORENE E. KENNEDY and HAROLD W. COLES

One of the objectives of Army Quartermaster research is increased knowledge leading to the improvement of specific end products, such as plastic materials. The migration of plasticizers—the blooming or exudation of the flexibilizing agent—is a frequent cause of the deterioration of the plastics. In studying this phenomenon it was deemed desirable to synthesize a variety of plasticizing compounds having the general characteristics of compatibility with high polymers, low vapor pressures, high polarity, and low freezing points.

The field of terpene chemistry was particularly attactive for the exploration of new plasticizers because (1) a homologous series of compounds could be readily prepared by well-investigated procedures, (2) terpenes, as a rule, are active solvents for organic high polymers, and (3) sufficient information was available to indicate that the compounds have other desirable properties as plasticizers, namely, fungistatic activity.

Other than camphor, slight attention has hitherto been paid to the terpene field in the search for new plasticizers. It is of interest to note that the diethyl- and the di-n-butyl esters of camphoric acid were introduced as commercial plasticizers in Germany during World War II apparently because no other flexibilizing agents were available for imparting to cellulose acetate those properties which are necessary in photographic and x-ray films.

Inasmuch as the work reported herein is preliminary in nature, the testing of the plasticizing action of the compounds was confined to a determination of compatibilities with selected high polymers, flexibilizing properties at low temperature and fungistatic activity.



EXPERIMENTAL

Terpene Carboxylic Acids

The d-camphoric acid was obtained from a commercial source and was of high purity. The camphenic acid was prepared (*1*) by oxidizing camphene

Table I. Properties of Terpene Carboxylic Acids

Terpene carboxylic acid	*M.p.*[a]	$[\alpha]_D^{20}$	*Neutr. equiv. Calcd.*	*Neutr. equiv. Found*	*Origin*
d-Camphoric acid, $C_{10}H_{16}O_4$	187°	+47.1	200.23	200.4	Commercial product
Camphenic acid, $C_{10}H_{16}O_4$	136.5–138°	...	200.23	201.2	Oxidation of com. camphene
Camphenonic acid, $C_{10}H_{14}O_3$	133–134°	...	182.00	182.0	Camphenic acid
Nopinic acid, $C_{10}H_{16}O_3$	128°	...	184.20	181.2	Beta-pinene from sulphate turpentine
dl-Pinonic acid, $C_{10}H_{16}O_3$	102–104°	−1.09°	184.20	184.5	alpha-pinene (wood turpentine)
"Liquid pinonic acid"	Liquid	+15.07°	...	206.8	alpha-pinene (wood turpentine)
dl-Pinonic acid, $C_{10}H_{16}O_3$	99.5–101.5°	...	184.20	184.0	crude sulphate turpentine
"Liquid pinonic acid"	Liquid	+23.5°	...	252.6	crude sulphate turpentine

[a] All melting points reported in this paper are uncorrected.

The compounds selected for investigation included certain esters of d-camphoric acid (I), its asymmetric isomer, camphenic acid (II), pinonic acid (III) and camphenonic acid (IV):

The possibility of using crude mixtures of terpene carboxylic acids, from an economy viewpoint, for starting materials was explored, and the esters thus prepared were compared with authentic compounds. Crude sulphate turpentine was studied as a convenient raw material for the preparation of pinonic acid.

Table II. Comparison of Pinonic Acids from Alpha-Pinene and Crude Sulphate Turpentine

Pinonic acid	*From alpha-pinene*	*From crude sulphate turpentine*
"Crude pinonic acid"[a]	50% yield	45% yield
dl-pinonic acid	25% yield	25% yield
melting point	102–4°C.	99.5–105.0°C.
$[\alpha]_D^{20}$	−1.09°C.	...
"Liquid pinonic acid"	25% yield	18% yield
$[\alpha]_4^{20}$	+15.07°C.	+23.5°C.
d_4^{20}	1.07667	1.07289
n_D^{20}	1.4682	1.4742
Neutr. equiv.	206.8	252.6

[a] Higher yields may be obtained by using the procedure of Dupont (*Ann. chim.* 1923 (ix) 19: 186).

Torsten Hasselstrom, Clifford E. Balmer, Norene E. Kennedy and Harold W. Coles, Quartermaster General Laboratories, Philadelphia, Pa.

Table III. Properties of Esters from Pure Terpene Carboxylic Acids

Ester	Boiling point °C., pressure in microns	Analysis calculated C, %	Analysis calculated H, %	Analysis found[b] C, %	Analysis found[b] H, %	d_4^{20}	n_D^{20}	Molecular Refraction Calcd.	Molecular Refraction Found
d-Camphoric-di-n-hexyl-, $C_{22}H_{40}O_4$[a]	159–161.5/65	71.69	10.94	70.60	10.37	0.96468	1.4597	104.47	104.46
Camphenic-di-n-hexyl-, $C_{22}H_{40}O_4$	156–157.5/165	71.69	10.94	71.88	10.98	0.9573	1.4541	104.47	104.51
Camphenonic-n-hexyl-, $C_{16}H_{26}O_3$	151–151.5/250	72.14	9.83	71.70	9.43	1.00154	1.4649	73.40	73.40
dl-Pinonic-n-hexyl-, $C_{16}H_{28}O_3$	140–141.5/55–60	71.59	10.51	71.86	10.16	0.95417	1.4561	75.43	76.47

[a] $[Alpha]_D + 18.95°$.
[b] Analyses by S. Sadtler & Sons, Philadelphia, Pa.

with alkaline potassium permanganate solution. The same procedure (*2*) was employed for obtaining nopinic acid from beta-pinene. Camphenonic acid was made by refluxing camphenic acid with acetic anhydride (*3*). The directions of Bayer et al. (*4*) were followed for preparing pinonic acid from alpha-pinene. The dl-pinonic acid separates as a solid from the crude vacuum-distilled acid mixture, the liquid part being a mixture of pinonyl formic, pinic, norpinic, and optically active pinonic acids (*5*). In this investigation the liquid part is designated as "liquid pinonic acid" and the crude terpene mixture as "crude pinonic acid." Table I records the properties of the acids prepared.

The observation was made that unrefined crude sulphate turpentine can be used with advantage as starting material for producing "crude pinonic acids." The acids are similar in composition to the product obtained from alpha-pinene (Table II). The divergences are of the order to be expected from the use of crude technical raw materials without refining. It should be noted that the mercaptan odor of the crude sulphate turpentine disappears during the oxidation step.

Esters of Terpene Carboxylic Acids

The method employed for the preparation of the esters involved refluxing the acid and alcohol in the presence of 0.02% of benzene sulphonic acid and a water-carrying-over reagent, xylene or toluene. After the esterification was complete the ester was purified by fractional distillation in a vacuum. Table III shows the properties of the esters obtained from pure acids and Table IV similar data for esters prepared from "crude" and "liquid" pinonic acid.

Table IV. Properties of Esters from Crude and Liquid Pinonic Acids

Ester	Boiling point °C., pressure in microns	d_4^{20}	
Pinonic-n-hexyl	113–114/260	0.9623	From alpha pinene ("Liquid pinonic" acid)
Pinonic-n-hexyl	138–145/350–375	0.97107	From crude sulphate turpentine ("Liquid pinonic" acid)
Pinonic-cyclohexyl	145/190	1.0246	From crude sulphate turpentine ("Crude pinonic" acid)
Pinonic-benzyl	160–190/200–250	1.0522	From alpha pinene ("Crude pinonic" acid)
Pinonic-benzyl	150–152/180	1.06965	From crude sulphate turpentine ("Crude pinonic" acid)
Pinonic-methyl	75–79/400	1.2638	From alpha pinene ("Crude pinonic" acid)
Pinonic-ethylenemonoethylglycol	120.5–121.5/100–150	...	From alpha pinene ("Crude pinonic" acid)
Pinonic-2-ethylhexylglycol	125–140/125–195	1.03266	From alpha pinene ("Crude pinonic" acid)
Pinonic-acid "terpene alcohol"[a]	118–184/260	1.04315	From alpha pinene ("Crude pinonic" acid)
Dihydrocumic-n-hexyl	129–133/175	0.96028	From nopinic acid (from beta-pinene-sulphate turpentine)

[a] The "terpene alcohol" is the poorly defined mixture of glycols and alcohols obtained on oxidation with potassium permanganate in neutral solution according to Delepine, et al., *Ann. chim.* 1943 (iv) 18: 250.

The alcohols employed were commercial products of high purity.

The d-camphoric-di-n-hexyl ester could not be obtained free of d-camphoric anhydride by distillation in a vacuum of the crude n-hexyl ester, regardless of whether the product was prepared by refluxing d-camphoric acid and the alcohol component in the presence of benzene sulphonic acid or obtained by reacting the di-silver salt of d-camphoric acid with n-hexyl iodide. This is in agreement with the previous observation of Brühl (*6*) that esters of d-camphoric acid are not stable to heat.

Solidification Points of Terpene Carboxy Acid Esters

The determination was carried out in the following manner: A test-tube containing about 2 ml. of ester was cooled in a mixture of dry-ice and ethyl ether and

Table V. Solidification Points of Terpene Carboxy Acid Esters

Test materials	Freezing points, °C.	Remarks
Pinonic methyl ester	−77	Crystalline
Pinonic ethylenemonoethyl glycol ester	−66	Noncrystalline
Pinonic benzyl ester	−52	Noncrystalline
dl-Pinonic n-hexyl ester	−79	Plastic below these temperatures
Pinonic n-hexyl ester (from liquid acid)	−75	Plastic below these temperatures
Camphenic di-n-hexyl ester	−79	Plastic below these temperatures
n-Butyl phthalate	−74	Crystalline
Methyl phthalate	−2	Crystalline
Commercial phthalate No. 1	−44	Nonplastic below these temperatures
Commercial phthalate No. 2	−36	
Commercial phthalate No. 3	−50	

Table VI. Fungicidal Activity of Test Compounds

Compound	Per cent inhibition
d-Camphoric-di-n-hexyl ester	6
Camphenic acid	7
Camphenic di-n-hexyl ester	9
Methyl salicylate	12
Nopinic acid	14
d-Camphoric acid	15
dl-Pinonic acid (from alpha-pinene)	15
Crude pinonic acid (from crude sulphate turpentine)	15
Pinonic ethylenemonoethyl glycol ester	20
Liquid pinonic acid (from alpha-pinene)	20
Pinonic methyl ester	26
Salicylic acid	40
Benzoic acid	42
n-Hexyl benzoate	48
Pinonic n-hexyl ester	50
dl-Pinonic n-hexyl ester	51
Pinonic benzyl ester	54

Table VII.

Ester	Clarity					Shrinkage, %					Flexibility at 20°C.					Flexibility below −50°C.					Origin
	Cellulose acetate	Cellulose triacetate[a]	Cellulose propionate	Polystyrene 1:4 ratio[a]	Polystyrene 1:3 ratio[a]	Polyvinylbutyral[a]	Cellulose acetate	Cellulose triacetate	Cellulose propionate	Polystyrene 1:4 ratio	Polystyrene 1:3 ratio	Polyvinylbutyral	Cellulose acetate	Cellulose triacetate	Cellulose propionate	Polystyrene 1:4 ratio	Polystyrene 1:3 ratio	Polyvinylbutyral			
d-Camphoric-di-n-hexyl-	NC	C	C	C	C	C			2				F	NF	F	NF	F	F	NF	F	NF	F	Commercial d-camphoric acid
Camphenic-di-n-hexyl-	NC	C	C	C	C	C	3						F	F	F	NF	F	F	NF	F	NF	F	Commercial camphene
dl-Pinonic-n-hexyl-		C	C	C	C	C	3		1				F	F	F	NF	F	F	NF	F	NF	F	alpha-pinene
Pinonic-n-hexyl-		C	C	C	C	C							F	F	F	NF	F	F	NF	F	NF	F	alpha-pinene "liquid pinonic" acid
Pinonic-n-hexyl-		C	C	C	C	C	2	7					F	F	F	NF	F	F	NF	F	NF	F	"Liquid pinonic" acid from crude sulphate turpentine
Pinonic-cyclohexyl-		C	C	C	C	C	2	10					F	F	F	NF	F	F	NF	F	NF	F	"Crude pinonic" acid from crude sulphate turpentine
Pinonic-benzyl-		C	C	C	C	C	2	12	1				F	F	F	NF	F	F	NF	F	NF	F	"Crude pinonic" acid from crude sulphate turpentine
Pinonic-benzyl-			C	C	C	C	2		1				F	NF	F	NF	F	F	NF	F	NF	F	alpha-pinene
Pinonic-methyl-			C	C	C	C			1				F	NF	F	NF	F	F	NF	F	NF	F	alpha-pinene
Pinonic-ethylenemonoethylglycol-			C	C	C	C							F	F	F	NF	F	F	NF	F	NF	F	alpha-pinene
Pinonic-2-ethylhexylglycol-			C	C	C	C	2	11					F	F	F	NF	F	F	NF	F	NF	F	alpha-pinene
Dihydrocumic-n-hexyl-		NC	C	C	C	C	3	10	1				F	F	F	NF	F	F	NF	F	NF	F	Nopinic acid from beta-pinene
Camphenonic-n-hexyl-			C	C	C	C	4	12					F	F	F	NF	F	F	NF	F	NF	F	Camphenic acid
Pinonic and "terpene alcohol"			C	C	C	C	5	5	1				F	F	F	NF	F	F	NF	F	NF	F	See Table IV
Commercial phthalyl plasticizer No. 1			C	C	C	C	2	2	2				F	F	F	NF	F	F	NF	F	NF	F	
Commercial phthalyl plasticizer No. 2			C	C	C	C	4	5	2				F	F	F	NF	F	F	NF	F	NF	F	
Commercial phthalyl plasticizer No. 3			C	C	C	C	3	10	2				F	F	F	NF	F	F	NF	F	NF	F	
Blank			C	C	C	C	4	7	3				F	NF	F	NF	NF	F	NF	F	NF	F	
n-Butyl sebacate																	F		NF		NF		

Legend: C = clear and compatible; F = flexible; NF = nonflexible.
[a] Cast on mercury.

a glass rod was moved slowly in the liquid. The temperature, at which the glass rod could not be moved due to crystallization or to the viscosity of the liquid, was recorded and designated as the solidification point. In Table V the values obtained for some of the terpene carboxylic acid esters are compared with some phthalic ester plasticizers.

Fungistatic Properties of Terpene Carboxylic Acids and Esters

Some of the terpene derivatives were tested for their fungistatic action. The screening procedure included the incorporation of the test compound into Czapek's agar in a concentration of 250 p.p.m., inoculation with *Aspergillus niger*, (QM 458) and incubation for 96 hours at 85 to 95°F. and 85 to 90% relative humidity. Results were calculated in terms of percentage inhibition based on the average diameter of the test plate colonies compared to the average diameter of the normal untreated controls and controls containing n-hexyl benzoate and methyl salicylate. The results are shown in Table VI.

Esters of Terpene Carboxylic Acids as Plasticizers in Films

Preparation of Films. A stock solution of the resin was made by dissolving 70 grams of the resin in 1000 grams of the solvent by mechanical shaking. To 53.5 grams of this stock solution was added 0.875 grams of plasticizer making the ratio of plasticizer to resin equal to 1:4. Duplicate 25-gram portions of the solution were poured into Petri dishes of 9.5 cm. diameter and the solvent allowed to evaporate over a period of approximately 3 days. The procedure is substantially the same as outlined by Reinhart et al. (*7*).

Evaluation of Films. Compatibility and clearness were determined by visual observation alone. Per cent shrinkage less than 3% was considered negligible. Flexibility at room temperature (20°C.) was determined by folding a square centimeter of the film on an axis first in one direction and then in the opposite direction. The film is folded again on an axis which is perpendicular to the first axis. Any break in the film by these Schopper folds caused it to be considered nonflexible, and any whitening indicated incompatibility.

To determine the flexibility below −50°C., 1 sq. cm. of the film was placed in a test tube which was immersed in a dry-ice acetone bath. After a period of approximately 5 minutes, the film was tested for flexibility as previously described but with the exception that the film after each folding was kept chilled for about 5 minutes. Table VII records the results obtained.

Infrared Absorption Curves

The dl-pinonic acid and "liquid pinonic acid" from alpha-pinene and crude sulphate

turpentine, and anisic acid were characterized by their infrared absorption curves.

It is of interest that the products derived from crude sulphate turpentine show a characteristic absorption band at 6.2 and 7.9 mu, which is indicative of anisic acid. This acid is the potassium permanganate oxidation product of methylchavicol (4-methoxyallylbenzene), which is a natural constituent of turpentine from slash and long leaf pines as described some years ago by one of us together with Hampton (*8*).

CONCLUSIONS

The preliminary evaluation of the plasticized films showed that all the esters were compatible with the cellulose esters tested with the exception of the n-hexyl esters of d-camphoric and camphenic acids, which caused blooming in acetate films of 53.2% acetyl content when employed in concentrations less than 1:4 ratio of plasticizer to resin. In polyvinyl butyral films the terpene carboxy esters were as efficient as the commercial phthalate plasticizer used as a blank. The esters, when incorporated in polystyrene films in a 1:3 ratio, showed the same behavior as n-butyl sebacate, but in lower concentrations produced less flexibility than the commercial product.

It was revealed that the n-hexyl esters of dl-pinonic acid exerted a fungistatic action comparable to esters of benzoic and salicylic acids.

The slight difference in plasticizer behavior between esters of pinonic acid prepared from alpha-pinene and from crude sulphate turpentine is attributed to esters of anisic acid and dihydrocumic acid, an unsaturated aromatic acid, deriving from nopinic acid, which is an oxidation product of beta-pinene. Nopinic acid yields dihydrocumic acid on dehydration because of the unstable hydroxy group in the "I"-position of the pinene nucleus (*9*).

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Tetrafluoroethylene Resin in Process Equipment

D. B. HANSON

Since its first uses in gaskets and packings for chemical process equipment, "Teflon" tetrafluoroethylene resin has been applied in a variety of places in the process industries. The product is completely inert to practically all chemicals and solvents, has outstanding heat-resistance and electrical properties, and has an unusual ability to resist sticking of very tacky materials. Discovered ten years ago, this resin is now in commercial production and has a bright future in many industrial uses.

"Teflon" tetrafluoroethylene resin was first made some ten years ago in the course of an extensive research program on fluorocarbon compounds being carried on in the Jackson Laboratory of the du Pont Company.

The gaseous monomer, tetrafluoroethylene, had been known for many years and was rather readily made by conversion of chlorodifluoromethane. However, it was widely believed among chemists that polymerization of the completely fluorinated ethylene molecule was impossible. Thus it was an important discovery that a solid polymer could be prepared with reasonable facility.

Characterization of the solid showed it to have such unusual and useful properties that immediate steps were taken to make additional quantities. Practical processes were developed by the Jackson Laboratory, for conversion of chlorodifluoromethane to the monomer and for polymerization to polytetrafluoroethylene. A pilot plant was built at the Arlington, N. J., plant of the Plastics Department in 1943, and its early production went entirely into critical war uses. Now a commercial production unit has been built at the new plant of the Polychemicals Department at Parkersburg, West Va., and operation of the new unit was begun in April, 1950.

METHODS OF HANDLING

Following the development of the method of making the polymer, the next problem was to devise methods of converting the granular powder into useful articles. "Teflon" is not adapted to fabrication by the conventional techniques used with other plastics, because the polymer does not melt and flow. On being heated to 327°C., however, it does undergo a solid-phase transition from the normal crystalline state to an amorphous gel, and in the gel condition the particles can be welded together into a solid mass.

It developed that the adaptable process of molding was much like that used in powder metallurgy. The granular powder is compressed under about 2000 p.s.i. into essentially the finished shape, at room temperature. The preform is then heated above the transition temperature, usually to about 360°C., to cause the solid particles to fuse together. Cooling the article completes the process. Details of the process will depend upon the article to be made; for example, thick sections are baked and cooled within the mold to avoid cracking. Even small pieces are sometimes "coined," that is, cooled under pressure in a die, to control shape and dimensions. Obviously the process is limited to the relatively simple shapes that can be formed from the cold powder.

D. B. Hanson, Polychemicals Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Extrusion of the granular polymer follows a similar procedure. The powder is fed to a cold cylinder, where a ram or screw compresses it and forces it into the die. It slips within the die into a heated zone, maintained at a temperature above the transition point for fusion, and finally into a cooling zone. The lack of fluidity again militates against production of complex cross sections and very thin walls. Production rates are of the order of 5 to 10 feet per hour.

Most articles of complicated shape are machined or otherwise formed from sheets, rods, or tubes. The plastic is machined quite readily by standard tools as long as they are kept sharp. Tape and sheet stock can be formed into simple curvatures by drawing in male and female dies.

FORMS AVAILABLE

Because of the unusual methods involved in the fabbrication of shapes and articles from the granular form all of the early work was carried on by du Pont. As the markets have grown, outside manufacturers have undertaken the molding, machining and extrusion of the product, and they are now supplying, on a commercial scale, various finished shapes, and standard sheets, rods and tubes in a wide range of dimensions. Du Pont no longer supplies finished shapes, and is taking steps also to discontinue molding and extrusion. By the end of this year it is expected that, of the various shapes heretofore offered, du Pont will be supplying only the film or tape, together, of course, with the granular molding powder from which all the shapes are made.

In August, 1949 a new form of the product was introduced, called "Teflon" suspensoid. The suspensoid is the same polymer manufactured previously, but in it the particles are so small that they can be suspended in water. The suspensoid, then, is an aqueous dispersion of the resin. It is adapted to impregnations, to mixing with fillers and other resins, to coating of surfaces by spraying and dipping, etc. The suspensoid polymer is used also in an extrusion compound for coating wire at much higher rates than have been possible with the granular polymer.

The Polychemicals Department are selling the raw suspensoid and extrusion compound. The Fabrics and Finishes Department are selling primers and finishes for spray application, wire-enamel primers, intermediates and topcoats, and coated glass fabrics, tapes and laminates, made from the suspensoid. The finishes are of particular interest because they can be used to produce coatings having good adhesion to metals, glass, porcelain and brick, and show unusual properties of antisticking, heat resistance, and anticorrosion.

PROPERTIES

Tetrafluoroethylene resin possesses a combination of properties that make it exceptionally useful for applications in process equipment.

1. Heat stability—the resin withstands continuous service at temperatures as high as 500°F. Also it has good toughness at low temperatures, and has been used in equipment handling liquid air.

2. Chemical resistance—the polymer is completely unaffected by all acids, alkalies, aliphatics, aromatics, and chlorinated hydrocarbons. It is, in fact, attacked only by molten alkali metals and by fluorine under pressure. Its water absorption is negligible.

3. Electrical properties—with a dielectric constant of 2.0–2.05 and a power factor of less than 0.0005 over the entire spectrum measured to date (60 cycles to 30,000 megacycles), it is one of the best insulating materials known. The electrical losses are unaffected by moisture, or by temperature up to at least 400°F.

4. Nonadhesive properties—the resin has an exceptionally slippery, waxlike surface that resists adhesion to a greater degree than any other material that we have encountered.

5. Miscellaneous properties—the resin weathers very well; samples have been found unchanged after five years of exposure in Florida. Its resistance to erosion by impinging fluids is outstanding. It exhibits low friction in rubbing against itself and other materials. Such properties have been very useful in specific applications, such as, respectively, jet evactors and packings.

6. Mechanical properties—the polymer is very tough, but in other physical properties is not outstanding. Its Izod impact values range from 2.0 at −70°F. to 6.0 at 170°F. When tested in a tensile machine the material begins to draw at loads of 1500 to 2500 p.s.i.

The molded or extruded polymer displays good resilience under moderate loading, but if loaded heavily enough to be deformed it will not recover completely unless heated. For example, a compressive load of 1000 p.s.i. results in a rapid reduction in thickness of 2 to 3%. Equilibrium is reached quite rapidly, and no further change will take place unless the load is increased or the temperature raised. Upon removal of the load, about $^2/_3$ of the deformation is recovered immediately, but there will be some permanent set at that temperature. At the same time, the material has perfect elastic memory, in that it will resume its exact original shape on being heated to 327°C.

APPLICATIONS

Applications for the resin fall into four general classes —chemical, nonadhesive, electrical, and wire-insulation. The chemical and nonadhesive properties in particular are being utilized in process equipment to reduce maintenance, increase productive capacity, reduce wear, simplify design, and avoid contamination of the product being handled.

The first commercial uses of "Teflon" were in gaskets for highly corrosive chemical service. It was found that gaskets of "Teflon" were essentially permanent unless damaged mechanically in repairing other parts of the equipment. A typical case is the gasket between sections of an evaporator for mixed nitric and sulphuric acids, where the temperature runs around 410°F. The maximum life of the asbestos gaskets previously used was one month, while the resin gaskets are giving a minimum of 18 months of service. Even at a cost ten times as high, its use was more than justified in this case.

Calculation of bolt loadings for solid gaskets of the resin may follow the procedure suggested in ASME Boiler Construction Code. The method requires knowledge of the "yield stress," that is, the minimum stress required to seat the gasket, and the "gasket factor," which is the required minimum ratio of pressure on the gasket to the internal pressure in the vessel.

It has been shown that, in general, the values used for compressed asbestos are applicable also to "Teflon." Comparing the compression characteristics of the two materials one finds that the resin is deformed at a constant rate with increasing load, while asbestos is compressed at a decreasing rate with increasing load. It is particularly interesting to note that when the load is relieved the two materials recover at practically the same rate.

Where extremely high pressures are to be held, the bolt loadings are so high that a "Teflon" gasket will be deformed to the extent that it squeezes out of the flanges. This can be avoided by confining the gasket in tongue-and-groove flanges. With such arrangement, resin gaskets have been used on equipment with internal pressure as high as 30,000 p.s.i. It is also helpful to use as thin a gasket as will accommodate the existing misalignment and roughness of the flanges. One-sixteenth inch thickness has been the most widely used.

Envelope gaskets were developed for glass, porcelain, and glass-lined equipment where the available bolt loadings are inadequate to seat the solid resin. These so-called "French" gaskets consist of a protective envelope of resin over a filler which lends the desired physical properties to the gasket. Soft fillers are used for glass flanges, and hard fillers for high-pressure flanges.

One manufacturer of alloy-steel valves has standardized on "Teflon" packing, and it is readily available from most valve manufacturers. The resin packing normally outlasts the valve, is universally adaptable to all chemical services, permits easy operation of the valve because of low friction on the stem, and requires no lubrication, thus avoiding any possibility of contaminating the product.

In packing for centrifugal pumps the resin has given phenomenal service life in the toughest of services. The following cases are typical of the savings that have been realized:

	Material pumped			
	Chlorinated benzol		*Hot H_2SO_4*	
	Conventional packing	*"Teflon"*	*Conventional packing*	*"Teflon"*
Cost per unit	$3.20	$31.20	$1.10	$11.28
Service life	Half week	30 months	Half week	27 months
Cost per month:				
Packing	25.60	1.04	8.80	0.42
Labor	24.00	0.10	24.00	0.11
Cost per month:				
Total	49.60	1.14	32.80	0.53
Cost for 30 months	1488.00	34.20	....	...
Cost for 27 months	.....	...	886.00	14.50
Savings	$1,450.00		$870.00	

Recently gaskets and packings of asbestos impregnated with the suspensoid polymer have become available. In these materials the resin affords protection against chemical attack on the asbestos, while the asbestos itself provides physical properties that are superior, for this type of use, to those of the solid forms of the resin. Another important point is that the cost of the impregnated asbestos is appreciably lower than that of tetrafluoroethylene resin.

The ability of the resin to help in handling sticky materials has opened the new field of so-called nonadhesive uses. Reduction of sticking can mean reduction of cost of maintenance, for cleaning equipment, and reduction of loss of product, as well as improvement in efficiency of operation and, frequently, in quality of product.

An outstanding application in this field is the replacement of stainless-steel rolls on bread-molding machines. In order to separate the wet sticky dough from the steel rolls, it was necessary to have accurately ground scrapers set against the rolls, and to keep the dough liberally dusted with flour. "Teflon" rolls have enabled the bakers to realize the following advantages:

(1) The maintenance cost of frequent regrinding of scrapers and occasional reconditioning of roll surfaces is eliminated, because the closely-set scrapers are not required.

(2) Productive capacity of the equipment is increased.

(3) The possibility of putting the sheeter out of commission by dropping foreign objects into the rolls is negligible, because the resin is resilient enough to permit such objects to pass through without damaging the rolls.

(4) The use of dusting flour is reduced.

(5) The quality of bread produced is improved because a thinner sheet can be rolled (this improves the texture of the bread by better degassing of the dough and by eliminating holes, streaks, and cores).

A nonadhesive application in the textile field is a covering for "slasher" drums. The wet yarn from the solution of sizing tends to stick to these drums and to leave a deposit of sizing. In many cases a covering of the polymer will eliminate this tendency.

On packaging machinery the resin is being used in guides, dead plates, hoppers, and folding arms, to reduce cleaning and improve operating efficiency.

The method by which the resin is applied for nonadhesive purposes varies widely. In general, the applications require covering a metal surface at critical points. Where the covering is not exposed to a great deal of abrasion or mechanical abuse, a "Teflon" finish is applied by spraying, and the resulting coating is baked *in situ* to provide a thin film with adequate properties. Frequently thick sections are required, and in such cases a sheet, rod, or tube attached by some mechanical means is the best answer. The bread-molder rolls, for example, are covered by molding a tube, with about one-half inch wall thickness, directly to a mandrel designed to fit the machine. Such technique is limited to relatively small rolls—up to about ten inches in diameter and twelve inches in length. Larger rolls, such as the "slasher" drum, can be covered with a spiral wrap of tape with mechanical attachments at the ends and, occasionally, a pressure-sensitive adhesive to aid in holding the tape in place.

In the electrical field the resin is filling a long-standing need for a mechanically tough insulation that will withstand high service temperatures. While certain insulations such as mica are, in themselves, very heat-resistant, their physical form requires that much less heat-resistant binders be used in conjunction with them. Thus the resin does permit designing electrical equipment to operate at higher temperatures and, concurrently, to produce more power in a given space, than has heretofore been possible.

The resin in the form of tape is very excellent for

wrapping conductors and coils in motors and generators. It is mechanically strong, easy to handle in wrapping operations, and, because of its flexibility, conforms well to odd shapes. Furthermore, its toughness permits coils to be shaped after the taping operation.

One manufacturer set out to design an electrically-heated portable steam generator. He needed a material that would insulate the electrodes going into the generator tank and isolate the generator tank from all other parts of the equipment. At the same time the material was required to serve as a gasket to hold steam at pressures up to 500 p.s.i. "Teflon" was the only material found to do the job, and without it his design would not have been practicable.

Modern communications equipment demands insulating materials with extremely low losses at high frequencies. "Teflon," polythene, and polystyrene all have suitable electrical properties, but only "Teflon" has the heat resistance and toughness requisite for certain applications. A good example is found in a television broadcasting station, where the transmission line running to the antenna operates at high temperatures. Formerly ceramic spacers were used in this coaxial cable. Spacers of the resin have a dielectric constant only one third that of the ceramic and greatly improve the efficiency of the cable, permitting the transmitter to be operated at a lower power level.

Another important use for the resin is as the insulation in coaxial connectors for radar equipment. The insulation must have some flexibility because the function of the connector is to attach a flexible cable to a rigid housing. It must also be heat-resistant, to avoid melting when connections are soldered during assembly. Also a certain amount of resilience and toughness are necessary, and the resin of all the materials available, possesses the best combination of properties to meet these requirements.

The foregoing examples show the versatility of tetrafluoroethylene resin for industrial uses. In every case a problem was solved that resulted in an appreciable saving to the user. The suspensoid polymer opens up new possibilities in coating and impregnation and in combining tetrafluoroethylene resin with other materials of construction.

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Studies on Lignin and Related Products

VI. The Oxidation of Fermented Sulphite Spent Liquor with Cupric Oxide Under Pressure

IRWIN A. PEARL and DONALD L. BEYER

A series of experiments was made on the oxidation of *Torulopsis utilis*-fermented sulphite spent liquor with copper hydrate and alkali under pressure at elevated temperatures. Variables considered were molar ratio of copper hydrate to lignin, molar ratio of caustic to lignin, time, and temperature. Total yields of ether-soluble material and of vanillin were determined for each set of conditions. For purposes of this investigation, the unit molecular weight of lignin was defined as that weight which contains one methoxyl group, assuming that lignin contains 14.5% methoxyl. Thus, the unit molecular weight becomes 214. Yields of total guaiacyl products pass through a maximum at a sodium hydroxide-lignin molar ratio of approximately 12. The corresponding vanillin yields on the lignin basis are a maximum when the sodium hydroxide-lignin ratio is about 13. Highest yields were obtained with a copper hydrate-lignin ratio of 13.5.

Recent isolations in good yield of several guaiacyl compounds other than vanillin from oxidations of lignosulphonate products with mercuric and silver oxides (*1*, *2*, *3*) prompted the reinvestigation of the oxidation of lignosulphonate materials with freshly prepared cupric oxide.

Preliminary experiments on various types of liquor indicated that, unlike the silver oxide oxidation of fermented sulphite spent liquor (*3*), the cupric oxide oxidation of fermented sulphite spent liquor gave results which were apparently uninfluenced by the nature of the sulphite cook prior to fermentation. Several types of liquors gave essentially identical results when exposed to pressure cupric oxide oxidation under the same conditions.

The data from an introductory series of pressure oxidations suggested that variations in the reactant ratios and reaction conditions greatly affected the yields of desired products, and that a much more satisfactory set of proportions and/or reaction conditions might be found which would give higher yields of the desired products than did the proportions and conditions of the earlier work (*4*). In our past work on metallic oxide oxidations of lignin materials (*1*, *3*), it was arbitrarily assumed that lignin had a unit molecular weight of approximately 180 (*5*) and all molar ratios of lignin were calculated on that basis. All lignin values for sulphite spent liquors have been calculated from methoxyl analyses, assuming that 10% of the methoxyl of the liquor did not belong to lignin and that lignin has a methoxyl content of 14.5% (*6*). If each lignin unit is to contain at least one methoxyl group, the above two assumptions do not agree. For the purposes of our further oxidation work, we are assuming the 14.5% methoxyl value for lignin to be correct. If we define a "unit molecular weight of lignin" as that amount of lignin containing one methoxyl group, then the value for the "unit molecular weight of lignin" must be (31)(100)/14.5 or 214. All molar ratios of lignin in this study are calculated on this basis.

Irwin A. Pearl, Technical Associate, and Donald L. Beyer, Technical Associate, The Institute of Paper Chemistry, Appleton, Wis.

This process was found in the past to result in high yields of vanillin (by analysis) (*4*). In the earlier work the cupric oxide employed was prepared by the reaction of cupric sulphate solution with aqueous sodium hydroxide. This process for the preparation of cupric oxide has two marked disadvantages. Firstly, hydrated cupric sulphate is not very soluble in water, and reactions employing this process for the preparation of cupric oxide are limited to dilute solutions. Secondly, the reaction mixtures contain considerable sodium sulphate. Within the past several years, hydrated cupric oxide or cupric hydroxide [$Cu(OH)_2$] (commercially designated as copper hydrate) has become available commercially as a

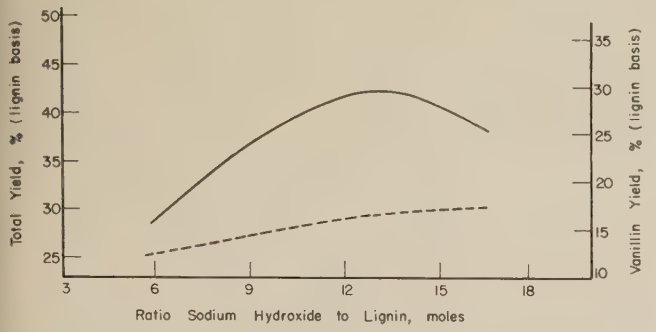

Fig. 1. Yields with various sodium hydroxide : lignin ratios. Experiments 1–9. Copper hydrate : lignin ratio constant at 4.8

free flowing blue powder. This material, which reverts to cupric oxide with loss of water upon heating, appeared to be ideally suited to our needs and, accordingly, it was employed in all experiments reported herein.

Preliminary experiments on the oxidation of fermented sulphite spent liquor and on basic calcium lignosulphonate with copper hydrate at atmospheric pressure indicated that the atmospheric pressure process was not a "vanillin" process and, as far as conversion of lignin to guaiacyl compounds was concerned, was not a very good process. Because earlier work (*4*) indicated that freshly prepared cupric oxide under pressure gave much higher yields of vanillin from various lignin materials than did corresponding treatments at atmospheric pressure, a study was made on the oxidation of *Torulopsis utilis*-fermented sulphite spent liquor with copper hydrate under superatmospheric pressure.

In the last paper (*3*) a series of experiments on the variables of the silver oxide oxidation of basic calcium lignosulphonate at atmospheric pressure was reported. It was desired to obtain the same type of information for the copper hydrate or cupric oxide oxidation of fermented liquor under pressure. In addition, this information was desired to help answer a number of questions arising in connection with the design of a pilot plant for the production of vanillin from fermented liquor by the cupric oxide procedure.

In the silver oxide series at atmospheric pressure, only two variables were considered—namely, the ratio of oxidant to lignin and the ratio of caustic to lignin. In a similar cupric oxide series under pressure, two additional variables—time and temperature—had to be considered. In the case of the time variable, the recorded value was arbitrarily taken as that time at which the reaction mixture was maintained at the designated temperature for the experiment. It is recognized that at least a part of the time necessary to reach the given temperature and for cooling might be considered reaction time and should not be disregarded in an evaluation of the data. For a standard experiment at 170°C. the time required to reach 170°C. was approximately 1 hour and the time required for the reaction mixture to cool below 100° was approximately 1.5 hours.

The series of experiments reported herein was made on a fermented liquor which was the effluent from the commercial yeast plant operated by the Lake States Yeast Corp. at Rhinelander, Wis. This liquor contained 25.8 grams of lignin per 1000 grams of liquor. Each experiment was performed in essentially the same manner on 2800 grams of the fermented liquor containing 72 grams (0.336 mole) of lignin.

PROCEDURE

In a standard experiment the mixture of liquor, 116 grams (2.8 moles) of sodium hydroxide, and 157 grams (1.6 moles of copper hydrate) was placed in an Alberger 1-gallon stainless steel autoclave. The autoclave was equipped with a motor-driven stirrer, a pressure gage, a thermometer well in which a Weston metal thermometer was placed, a pressure relief valve, and a rupture disk assembly which was fitted with a Monel metal disk recommended for temperatures over 200°C. at which temperature it will withstand a pressure of 900 p.s.i. An asbestos gasket was centered in place and the top of the autoclave was securely tightened with eight bolts. The pressure relief valve was closed and the motor-driven stirrer started. The heat was derived from a direct-firing ring-type gas burner. The gas burner was attached to a ring stand, enabling it to be

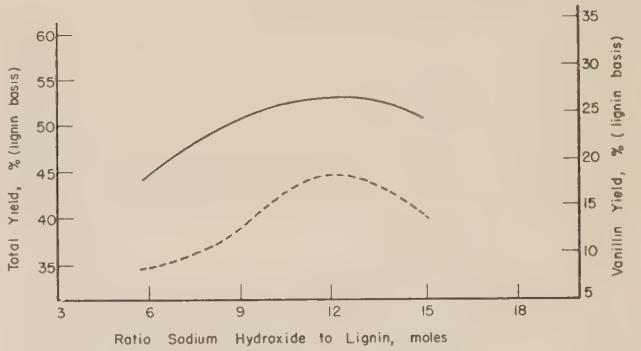

Fig. 2. Yields with various sodium hydroxide : lignin ratios. Experiments 36–40. Copper hydrate : lignin ratio constant at 11.3

adjusted within a range of 1 to 6 in. below the bottom of the autoclave. The mixture was heated to 170°C., held at this temperature for a period of 5 hours, and allowed to cool with stirring. Pressure and temperature readings were taken every 30 minutes. When cool, the autoclave contents were removed and filtered, and the cuprous oxide sludge was washed thoroughly with water. The filtrate and washings were well mixed and a one-fourth aliquot (containing 18 grams of lignin) was taken for evaluation. This aliquot was acidified with dilute sulphuric acid and diluted to 1 liter. The liter of acidified mixture was continually extracted with ether for 16

hours in the air-agitated continuous liquid-liquid extractor (*7*). The ether extract was dried with anhydrous sodium sulphate and then distilled to dryness on the steam bath, finally under reduced pressure. The product was dried in a vacuum desiccator and weighed.

Methoxyl determinations on several of these products indicate that they are chiefly guaiacyl in nature and other experiments suggest that almost all the non-guaiacyl portion consists of oxalic acid. Inasmuch as the data of this series were to be used for planning a pilot-plant procedure for the production of vanillin from fermented sulphite waste liquor, the vanillin content of the products of the individual experiments was determined.

VANILLIN DETERMINATION

In the beginning, two gravimetric procedures—namely, the 2,4-dinitrophenylhydrazine and the *m*-nitrobenzhydrazide methods—were tried. The yields obtained were very high and isolation experiments could not confirm these yields. It is well known that other compounds, such as acetovanillone and various organic acids and carbonyl compounds, will give precipitates with these reagents. Even with pH control and other precautions recommended by various authors, these procedures could not be modified to give accurate vanillin results. Recourse was made to the volumetric procedure for vanillin originally described by Ripper (*8*).

This so-called rapid vanillin assay was performed as follows: Approximately a $^1/_2$-gram sample was weighed on an analytical balance. The sample was dissolved in a minimum of *N* sodium hydroxide (usually 24 hours' standing at room temperature was required for complete solution) and was acidified with sulphur dioxide gas. An excess of potassium iodide (2 grams) was added, together with a little starch indicator. The mixture was

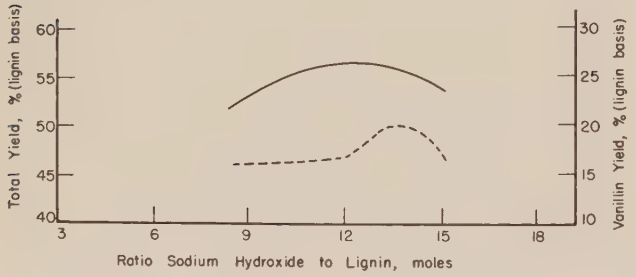

Fig. 3. Yields with various sodium hydroxide : lignin ratios. Experiments 41–45. Copper hydrate : lignin ratio constant at 14.3

cooled to 6°C. and titrated (while maintaining the temperature at 6°C.) with 5% potassium iodate solution almost to the end point. The titration was finished with 0.1 *N* iodine solution. While still cold, a known amount of standard iodine solution was then added, followed by 10 ml. of hydrochloric acid. The mixture was warmed to 35°C. on the steam bath and allowed to stand exactly 5 minutes. The mixture was then back titrated with 0.1 *N* standard sodium thiosulphate solution. The amount of standard iodine consumed by the decomposition of the vanillin bisulphite addition product is thus measured. Each cubic centimeter of the 0.1 *N* iodine is equivalent to 0.0076 gram of vanillin. It must be noted, however, that this procedure measures any aldehyde capable of forming bisulphite addition complexes in solution and not only vanillin. However, results obtained by this method in recovery experiments with pure vanillin indicate that the procedure accounts for only 90 to 95% of the vanillin. Because the other aldehydes capable of forming bisulphite addition products which might be present in the ether-soluble material probably represents only a fraction of a per cent of the total, the rapid vanillin assay is a good procedure for evaluating the vanillin content of these reaction

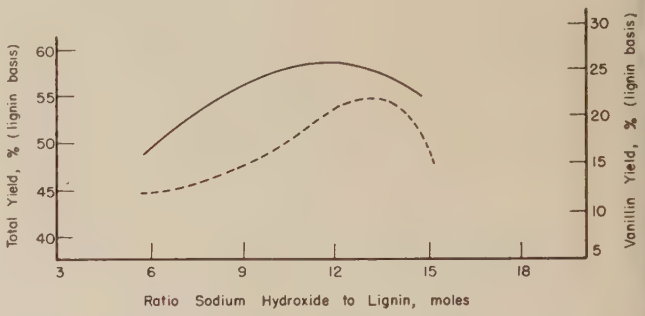

Fig. 4. Yields with various sodium hydroxide : lignin ratios. Experiments 46–51. Copper hydrate : lignin ratio constant at 13.5

mixtures. Moreover, actual vanillin isolations from several of these total ether-soluble products have equaled the vanillin assay. We are convinced that the vanillin assays reported in this series are actually low values of the actual vanillin content of the liquors, but do represent the amounts of vanillin which may be isolated in a pure form by methods known to date and employed in the work up of isolated fractions.

The effects of varying conditions upon this standard experiment were studied by changing one or more of the following: reactant ratios, time, and temperature. The results of these experiments are given in Figs. 1 through 10. In these experiments it should be noted that the only factors which could be controlled exactly and duplicated were the weights of reactants. The other factors or variables in the procedure offered possibility for experimental error. For example, the source of heat was obtained from a ring gas burner. The fluctuating pressure in the gas mains, together with the heat loss due to radiation, made it almost impossible to maintain a steady constant temperature for 5 hours. Consequently, a temperature range of ±10°C. must be considered for each reaction. Another source of possible experimental error arises in attempting to duplicate the extraction procedure. The air-agitated extractor was used in each case. The rate of extraction is influenced by the rate of flow of the air. However, it is believed that, after 16 hours, the extraction, if not entirely complete, is so nearly complete that any remaining ether-soluble material is negligible.

EFFECT OF VARYING SODIUM HYDROXIDE LIGNIN RATIO

Experiments 1–9 embrace a series of oxidations at 170°C. for 5 hours in which the copper hydrate-lignin ratio is maintained constant at 4.8, while the sodium

hydroxide-lignin ratio is varied between 6.0 and 16.4. The total yield of guaiacyl products (it is realized that a portion of this material is aliphatic in nature) passed through a maximum at a sodium hydroxide ratio of 13.4, but the vanillin yield on the lignin basis maintained a steady increase. It is apparent that increased caustic increases the degradation of lignin to vanillin, even though it does not increase the total yield of ether-soluble degradation products. These data are shown in Fig. 1. It should be noted that the rate of increase in total yield up to the maximum is much higher than the rate of increase in vanillin yield.

A preliminary series on the variation of yields varying copper hydrate-lignin ratios at a constant sodium hydroxide-lignin ratio of 8.3 indicated that yields increased at higher copper hydrate-lignin ratios. Therefore, the effect of alkali-lignin ratios was studied at higher copper hydrate-lignin ratios. Three series on the variation of yields for oxidations at 170°C. for 5 hours with changing sodium hydroxide-lignin ratios at constant high copper hydrate-lignin ratios of 11.3, 14.3, and 13.5, similar to the series portrayed in Fig. 1, are given in experiments 36 to 51 and pictured in Figs. 2, 3, and 4, respectively. It is evident from the studies at all three copper ratios that yields of total guaiacyl products go through a maximum at a sodium hydroxide-lignin molar ratio of approximately 12. The corresponding vanillin yields on the lignin basis go through a maximum when the sodium hydroxide-lignin ratio is about 13. Highest yields were obtained with a copper hydrate ratio of 13.5.

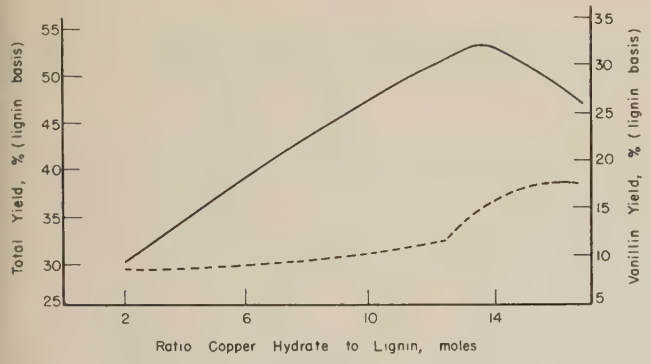

Fig. 5. Yields with various copper hydrate : lignin ratios. Experiments 10–20. Sodium hydroxide : lignin ratio constant at 8.3

EFFECT OF VARYING COPPER HYDRATE-LIGNIN RATIO

Experiments 10 to 20 (Fig. 5) comprise a similar series of oxidations at 170°C. for 5 hours in which the copper hydrate-lignin ratio is varied from 2.4 to 16.6, while the sodium hydroxide-lignin ratio is held constant at 8.3. Whereas the total yield increased uniformly up to a maximum of 53.5% at a ratio of 13.5, the vanillin yield remained almost constant until the copper oxide ratio reached about 12.8. It is evident that, before this point, the copper oxide under pressure must degrade a considerable portion of the lignin nucleus to monomolecular products other than vanillin.

The next three series (embodied in experiments 52 to 68) comprise experiments on the variation of yields for oxidations at 170°C. for 5 hours with changing copper

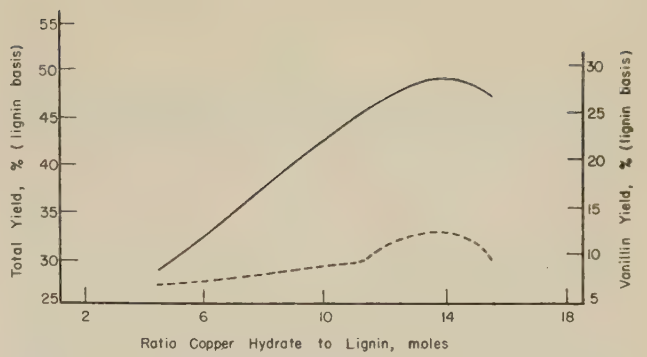

Fig. 6. Yields with various copper hydrate : lignin ratios. Experiments 52–55. Sodium hydroxide : lignin ratio constant at 6.0

hydrate-lignin ratios at constant sodium hydroxide-lignin ratios of 6.0, 11.9, and 13.4, similar to the series of experiments 10 to 20 (Fig. 5). The data for these three series are shown in Figs. 6, 7, and 8, respectively. The yields in all three series went through a maximum at a copper hydrate-lignin ratio of approximately 13.5. This was true of the vanillin yield as well as of the total yield. The highest over-all yield of 58.1% was obtained with a sodium hydroxide-lignin ratio of 11.9 and a copper hydrate-lignin ratio of 13.5, and the highest vanillin yield of 21.5% was obtained with a sodium hydroxide-lignin ratio of 13.4 and a copper hydrate-lignin ratio of 13.5. It is possible that these yields could be increased further by time and temperature studies at these optimum concentration ratios.

Several experiments were made with cupric oxide which had been recovered from the cuprous oxide sludge from the above described experiments by roasting in a current of air. The recovered cupric oxide was a fine, fluffy black powder, and was easily adapted for use in this process. The data of these experiments indicate that this recovered copper oxide apparently may be substituted for the original copper hydrate in the same molecular proportions.

EFFECT OF TEMPERATURE

In experiment 22 to 29 a study was made of the effect of temperature on the cupric oxide oxidation in which the sodium hydroxide-lignin ratio and the copper hydrate-lignin ratio were maintained constant at 8.3 and 11.3, respectively. In this series, the times recorded are all 0, that is, the reaction mixtures were brought up to the specified temperature at the same rate and allowed to cool. It should be understood that the experiments at the higher temperatures had correspondingly

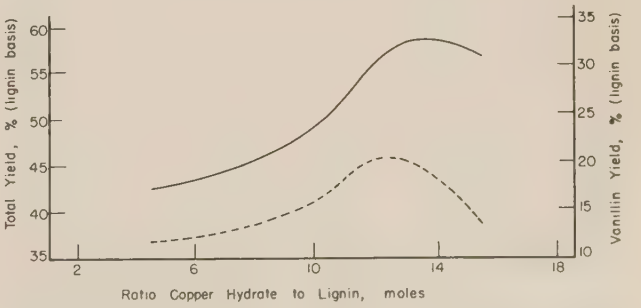

Fig. 7. Yields with various copper hydrate : lignin ratios. Experiments 56–61. Sodium hydroxide : lignin ratio constant at 11.9

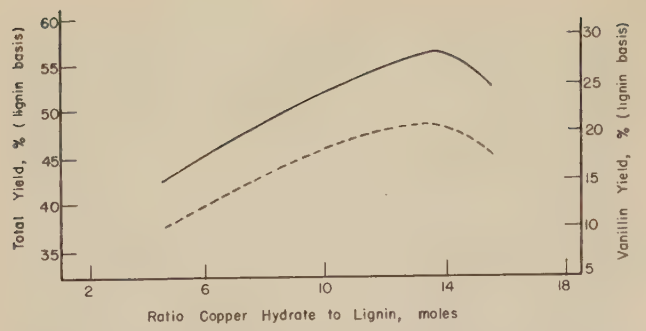

Fig. 8. Yields with various copper hydrate : lignin ratios. Experiments 62–68. Sodium hydroxide : lignin ratio constant at 13.4

longer reaction times and it is entirely possible that the longer reaction time was responsible for the nature of the results. For example, if 170°C. is optimum for high yield, then the length of time that the 190°C. experiment was over 170°C. during both the heating and cooling operations might account for the better results at that temperature. These factors should be kept in mind when evaluating this series of experiments. In any event, as shown in Fig. 9, as the temperature increased to 190°C. the yields of both total guaiacyl products and vanillin increased but at a very different rate. When the temperature went above 190°C. both yields decreased, thereby suggesting that the desired products were further oxidized or degraded at the higher temperatures. Demethylation begins to occur at temperatures approaching 200°C. and it is very probable that at least a part of the decrease in yield might be attributed to the greater preferential solubility of the catechol derivatives in water with respect to ether.

This series of experiments employed the arbitrary values of 8.3 and 11.3 for the sodium hydroxide and copper hydrate ratios, respectively, because, at the time the series was started, they appeared to give the best results. Later work indicated other ratios to be better.

EFFECT OF TIME

Experiments 30 to 35 (Fig. 10) comprised a study of the effect of varying times of reaction upon the oxidation at 170°C., employing the same arbitrary ratios of sodium hydroxide to lignin (8.3) and copper hydrate to lignin (11.3) as in the temperature study. Again, this series was begun before the optimum ratios were determined. The data for these experiments reveal that, at 170°C., maximum yields are obtained in less than 2 hours and that the 5 hours of reaction time employed as

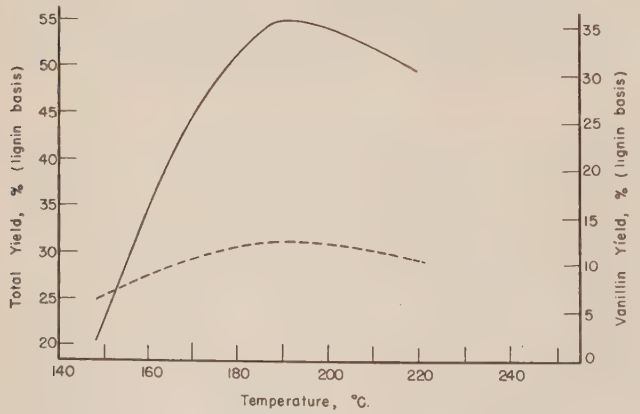

Fig. 9. Yields at various temperatures. Experiments 22–29. Sodium hydroxide : lignin ratio 8.3; copper hydrate: lignin ratio 11.3

standard in most of our other experiments was unnecessary but was apparently innocuous, especially at temperatures as low as 170°C.

Of all the experiments reported in this paper, experiment 59 employing a sodium hydroxide-lignin ratio of 11.9, a copper hydrate-lignin ratio of 13.5, a temperature of 170°, and a heating time of 5 hours gave the largest over-all yield of ether-soluble material. Similarly, experiment 66, employing a sodium hydroxide-lignin ratio of 13.4, a copper hydrate-lignin ratio of 13.5, a temperature of 170°C., and a heating time of 5 hours gave the maximum yield of vanillin.

Generally speaking, the products from the experiments reported herein were semisolid from those employing high sodium hydroxide-lignin ratios and solid from those employing lower (8.3 and less) sodium

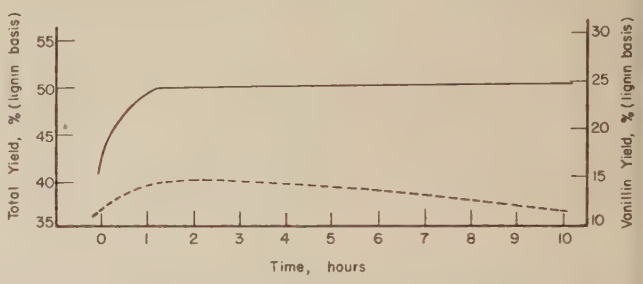

Fig. 10. Yields with various times. Experiments 30–35. Sodium hydroxide : lignin ratio 8.3; copper hydrate : lignin ratio 11.3

hydroxide-lignin ratios. Preliminary tests indicated that, for the most part, the solid products contained relatively high proportions of vanillic acid, whereas the semisolid products contained less of this compound. The fractionation of these products and the identification of new compounds will be described in future papers.

It is realized that the experiments described in this paper constitute only a beginning, and that many more are required to obtain a complete picture of the process. If vanillin is to be the only product of interest, emphasis will have to be placed on the factors giving highest vanillin yields. However, if vanillic acid is to be the goal, the products obtained in the experiments described herein will have to be re-evaluated for vanillic acid, and other factors will have to be emphasized in future work. Actually, the latter alternative is being investigated at present and will be reported in the future.

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The Mechanical Properties of Paper-Base Laminates

M. P. SEIDEL

Phenolic resin-bonded laminates were made using saturation-type papers of eight different commercial pulp stocks. These papers were of comparable thickness, high porosity, low density, and minimum grain. The properties studied were tensile, flexural, impact, and bond strengths. Significant differences due to fiber orientation, length, and refining were observed.

THE three most important uses of commercial laminates of the paperphenolic resin type are for decorative, electrical, and mechanical applications. Many factors must be considered before a particular filler-resin combination may be used practically, but no matter what the end use may be, the material must be supported or fastened in some way. In many cases it is

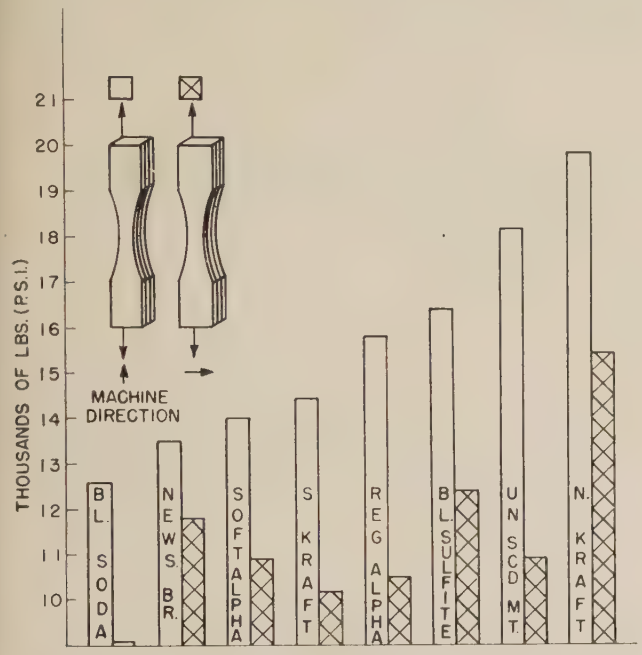

Fig. 1. Average tensile strength of phenolic laminates

sufficient that the laminate support its own weight although more often the innate properties of the laminated part must contribute additional strength or rigidity to the composite. Laminates are rarely used in tension; however, compression and impact strengths of laminated parts are important both for the high-speed assembly and the durability of modern machinery. The physical properties of laminates must also be sufficient to resist dimensional changes which are encountered because of temperature and humidity cycling.

SAMPLE PREPARATION AND TESTING

The four mechanical properties of the laminates which were measured were tensile, flexural, impact, and bond strengths. The paper and treating machine direction of the paper was preserved in laying up the laminate, and tests were made on specimens both normal and parallel to the machine direction.

M. P. SEIDEL, Westinghouse Research Laboratories, East Pittsburgh, Pa.

The methods used to treat and laminate the boards have already been described (*1*). The quarter-inch boards were laminated for 35 minutes at 1000 p.s.i.g. at 170 to 175°C. and the half-inch boards were laminated for 50 minutes under these conditions.

Boards from which tensile-strength specimens were cut were 0.25 inch thick and boards used to furnish samples for all other tests were 0.50 inch thick. The samples were cut by means of a high-speed, water-cooled abrasive disk, and all cutting and machining was done before sample conditioning. The samples were conditioned by immersion in water for 24 hours followed by a 3-month exposure to a 50% relative humidity atmosphere at room temperature.

Each experimental point reported in accompanying data compilations is the arithmetic average of tests made on five separate specimens, and all tests were run by A.S.T.M. methods (*2*).

The tensile-strength values for the eight boards studied are reported in Fig. 1. Values are given for samples taken both parallel and normal to the original machine direction of the paper. One of the objectives of the present study was an attempt to eliminate fiber orientation effects in the finished laminate. This goal was achieved in the formation of the papers themselves, but orientation recurred during some stage of the conversion process. It is likely that both the compression imposed on the paper during its passage through the treating machine squeeze rolls as well as the tension applied during the resin-drying stage were instrumental in imparting anisotropy. If this mechanism is correct it is evident that the several papers studied have undergone such processing to varying degree. Thus the ratio of the grain parallel to grain normal tensile strengths varies from 30 in the case of the bleached soda boards to 2 for the broke newsprint. No regularity in

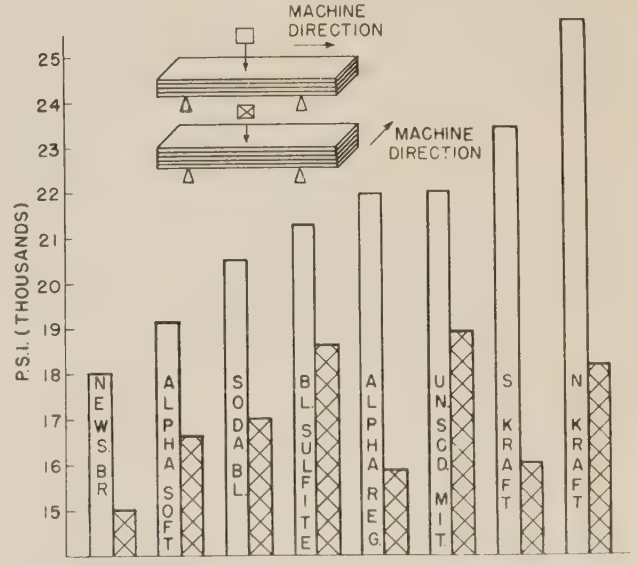

Fig. 2. Average flexural strength of phenolic laminates

Table I. Newsprint

	Tensile		Flexural		Impact				Bond	
	w. g.	*c. g.*	*f. w. w. g.*	*f. w. c. g.*	*f. w. w. g.*	*e. w. w. g.*	*f. w. c. g.*	*e. w. c. g.*	*w. g.*	*c. g.*
Average	13,534	11,808	18,076	14,994	6.648	2.108	6.319	2.025	697	603
Standard deviation	997	237	1,643	808	0.559	0.029	0.123	0.002	39	52

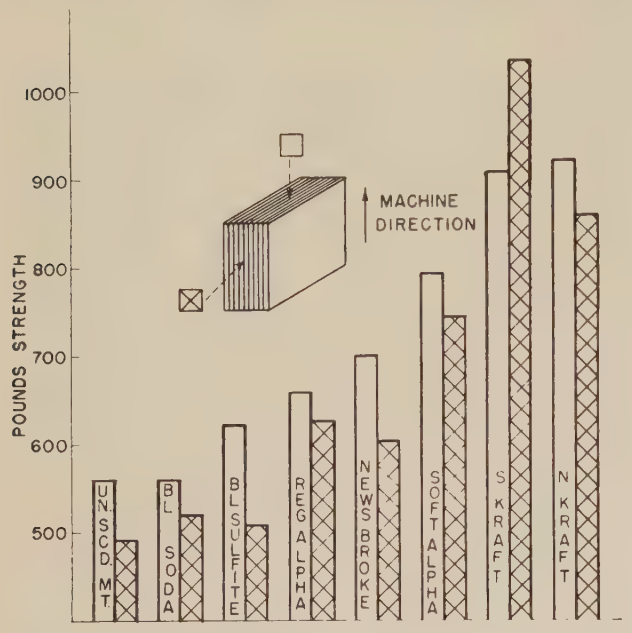

Fig. 3. Average bond strength of phenolic laminates

this ratio is evident, and the existence of this ratio must be due to some fundamental property of the paper fibers.

The machine parallel tensile strength of the boards varies from 12,500 to 20,000 p.s.i., and there are marked differences between boards made from pulps of slight variation. Thus northern kraft has 150% of the strength of southern kraft, and regular alpha has a higher strength than soft alpha. In the case of the alpha papers the normal machine-direction strength is the opposite of that of the parallel machine value. Both the newsprint and the northern kraft retain a high percentage of their tensile strength in the cross grain direction.

Figure 2 summarizes the flexural strength data obtained on the eight papers investigated. The effect of machine direction which was observed in the case of the tensile strength studies is also evident in flexure. This effect is somewhat less pronounced in the latter case as is shown by the fact that the normal direction values are only 30 to 60% of the parallel direction values. The northern kraft board has the highest flexural strength but the southern kraft is now in second position, whereas this board had only intermediate tensile strength. The newsprint and soda papers are among the boards of low flexural as well as low tensile strength. The position of the two alpha stocks remains relatively constant.

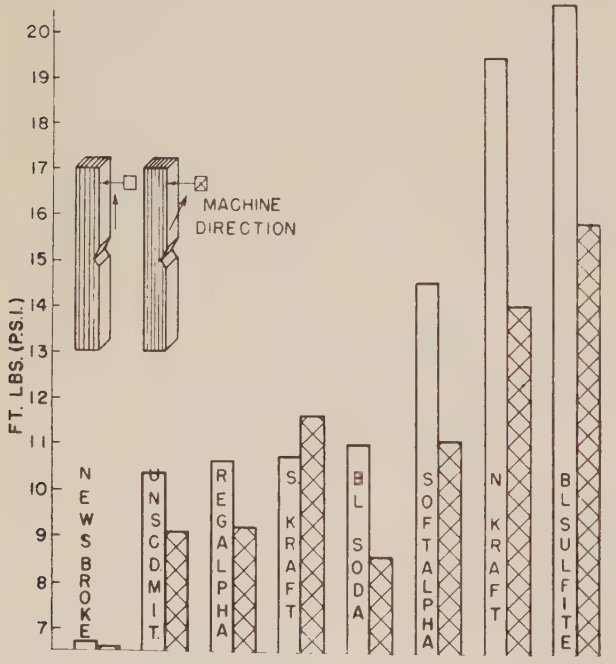

Fig. 4. Average Izod impact strength of phenolic laminates

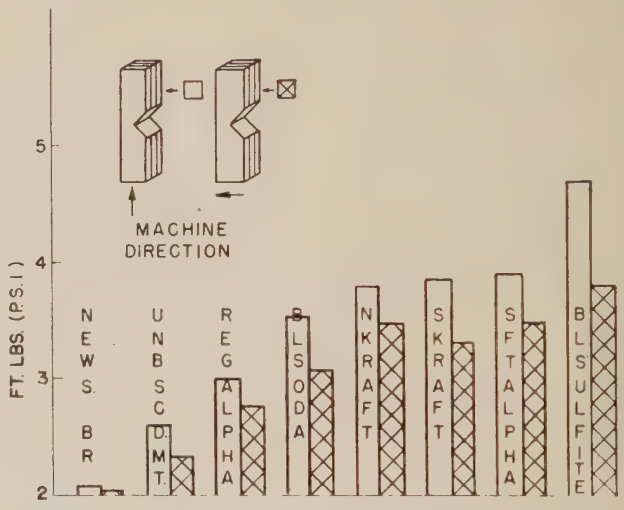

Fig. 5. Average Izod impact strength of phenolic laminates

The parallel and normal bond strength values are summarized in Fig. 3. In this study, in contrast to the data of Figs. 1 and 2 in which fiber length and orientation were probably the governing fundamental properties, fiber bonding or adhesion is probably paramount (*3*). As supporting evidence for this theory the relatively minor effect of orientation in determining bond strength may be offered. Furthermore the bond strength of the newsprint which is known to have very short fiber length is considerably higher than would be reasonably expected. The noncellulosic constituents of

Table II. Northern Kraft

	Tensile		Flexural		Impact				Bond	
	w. g.	*c. g.*	*f. w. w. g.*	*f. w. c. g.*	*f. w. w. g.*	*e. w. w. g.*	*f. w. c. g.*	*e. w. c. g.*	*w. g.*	*c. g.*
Average	19,840	15,382	25,784	18,252	19.355	3.829	14,065	3485	920	866
Standard deviation	1,125	2,212	754	1,131	0.241	0.021	2.307	0.021	38	120

the newsprint and the kraft papers may serve as a plasticizer to produce a more homogeneous combination of resin and paper than is possible in a paper of high cellulose content. The anomalous condition which is shown by the southern kraft in which the normal value is actually greater than the parallel value gives further evidence in support of the adhesion testing character of this determination. In summation it may be said that the kraft papers are outstanding in bond strength, and the newsprint is higher than might be expected.

The Izod impact strength for these samples is illustrated in Figs. 4 and 5. A fair correlation exists between the flatwise and the edgewise impact strengths with the exception of northern kraft. This paper has 30% greater strength than the soft alpha in the flatwise test and approximately the same value in the edgewise test. The effect of grain is relatively unimportant in impact testing except in the case of the higher valued flatwise tests. The higher normal machine direction value for the southern kraft which was observed in the bond strength studies is again evident in the flatwise Izod test.

Tables I and II present the numerical average and standard deviation for a laminate of low mechanical properties (newsprint) and for a laminate of high mechanical properties (northern kraft). The standard deviation figures for the newsprint are from 1 to 10% of the averge values whereas in the case of the kraft the corresponding figures are 1 to 15%.

CONCLUSIONS

The mechanical properties of phenolic resin-bonded paper-base laminates are governed by the paper fiber, fiber length, fiber orientation, and fiber purity. Although the papers used are "grainless," orientation was imparted to the paper during the conversion processes. The mechanical properties of kraft papers bonded by means of a fast hard phenolic resin are outstanding. Noncellulosic components in the less highly refined papers may exert a plasticizing action on the binder.

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The Moisture Sorption and Dimensional Stability of Paper-Base Laminates

M. P. SEIDEL and R. H. RUNK

The water resistance of eight paper stocks used as phenolic laminate fillers are evaluated. Properties tested on totally immersed samples are as follows: weight gain (moisture sorption), increase in thickness (at center and at edges), increase in length (with grain), and increase in width (cross grain).

The resistance of paper-base laminates to moisture is of prime importance to the laminating industry. Sorbed water in laminates produces several highly undesirable conditions: (1) deterioration of dielectric properties, (2) dimensional changes leading to warpage, (3) blistering. The first listed difficulty is of primary interest in electrical insulating applications. The latter two are of primary interest in structural and decorative applications.

This report is a continuation of the work on paper-base laminates which was reported at the TAPPI meeting in 1949 (*1*). The previous work was concerned with the influence of bonding resin on the properties of a kraft paper-base laminate, whereas the present work emphasizes the effects of the type of paper used as filler in combination with a single phenolic resin.

PAPER FILLERS

The paper fillers for this investigation were prepared under carefully controlled conditions in the pilot plant of the Forest Products Laboratory, Madison, Wis. The types of pulp and other properties of the papers have been described in the first report of this series (*2*). For the sake of brevity we shall merely list the paper stocks used as follows: southern kraft, northern kraft, newsprint broke (80% groundwood, 20% bleached sulphite), bleached sulphite, regular alpha, soft alpha, unbleached Scandinavian Mitscherlich, and bleached soda pulp.

M. P. Seidel and R. H. Runk, Westinghouse Research Laboratories, East Pittsburgh, Pa.

PREPARATION OF RESIN

The resin binder consisted of a phenol formaldehyde polymer with a mole ratio of 1:1.25 synthetic phenol to formaldehyde. The catalyst used was ethylene diamine, 0.5% by weight based on the phenol.

After refluxing for 1 hour at 96°C. the liquid condensate was subjected to vacuum distillation (pressure of 10 mm. Hg) to remove water and other volatile products until the temperature reached 100°C. The liquid resin was then quickly cooled and diluted to 40% recoverable solids content by adding a mixture of alcohol and water (2:1 by volume).

Table I

Stock	*Resin content, %*	*Greenness, %*	*Volatile, %*
Core	45–47	3–6	1–4
Surface	58–63	1–3	3–6

Greenness: Per cent weight loss on laminating 10 to 15 grams stack 5 minutes at 1000 p.s.i. and 170°C.
Volatile: Per cent weight loss on heating one sheet of treated material 15 minutes at 115°C.

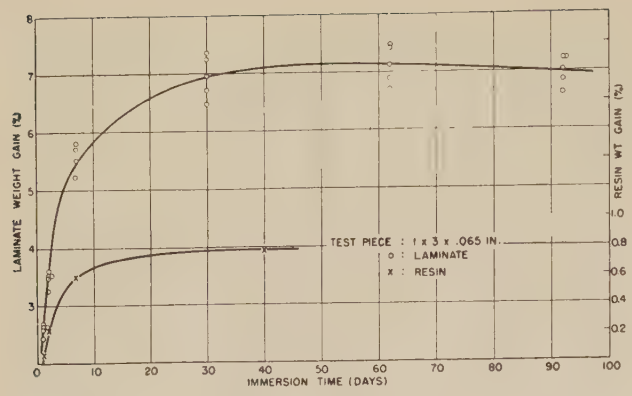

Fig. 1. Average moisture sorption of southern kraft base laminate at 25°C.

TREATING AND LAMINATING

The various paper stocks were impregnated with the phenolic varnish and dried in a 10-foot horizontal treating tower. Core stock was given a single dip and pass. Surface stock was prepared by retreating the core stock on one side only. All papers were treated as nearly alike and to the same limits as possible. Treating terms and values are given in Table I. Laminates were prepared by pressing a stack of core stock faced with two surface sheets between polished stainless-steel press plates. All sheets were stacked with the grain direction the same, and a marker was inserted to distinguish the grain direction. To insure even distribution of pressure, cushions of alpha-cellulose paper were inserted between the stack and the platens of the hydraulic press.

After the press had been closed to 1000 p.s.i. on the stack the temperature was raised to 170 to 175°C. in the board and maintained for 20 minutes. The laminate was cooled quickly to 50°C. or lower under pressure before opening. No parting aids or lubricants were used in the varnish or on the press plates.

PREPARATION AND TESTING OF SAMPLES

Test pieces were prepared as follows: (1) moisture sorption and swelling—pieces 1 by 3 by 0.065 inch, and (2) elongation—pieces 0.5 by 5.5 by 0.065 inch.

In testing, the pieces were totally immersed edgewise in distilled water at room temperature. Moisture sorption was determined by gain in weight as determined by weighing to the nearest milligram on an analytical balance. Dimensional changes were determined in a clamp jig to the nearest 0.1 mil by means of a dial gage.

Each of the values reported in the accompanying figures represents an average of determinations on five separate samples. In the data on swelling, tests on a number of samples were terminated before the end of the usual 90-day period because of severe blistering.

Table II. Average Moisture Sorption of Paper Laminates at 25°C.

Filler type	Per cent moisture sorption					
	1 Day	2 Days	7 Days	30 Days	60 Days	90 Days
Southern kraft	2.6	3.5	5.5	7.0	7.1	7.1
Northern kraft	1.8	2.3	5.7	8.3	8.5	8.8
Newsprint broke	1.6	2.4	5.3	9.1	9.6	9.9
Soft alpha	2.6	3.7	6.1	8.4	10.4	11.6
Regular alpha	2.7	...	9.0	12.7	14.9	15.1
Bleached sulfite	2.0	...	6.0	10.7	12.0	12.0
Unbleached Scandinavian Mitscherlich	2.1	...	6.5	11.2	13.8	14.5
Bleached soda	2.2	3.1	7.0	12.0	14.0	15.4

Table III. Average Center Swelling of Paper Laminates, Total Immersion in Water at 25°C.

Filler type	Per cent thickness increase at center					
	1 Day	2 Days	7 Days	30 Days	60 Days	90 Days
Southern kraft	0.7	1.1	2.3	3.6	4.0	3.8
Northern kraft	0.8	1.4	3.4	7.4	8.0	8.5
Newsprint broke	0.6	1.3	3.1	8.0	10.0	11.1
Soft alpha	1.6	2.4	4.7	11.3	B	..
Regular alpha	2.4	...	5.9	B	..	..
Bleached sulphite	1.1	...	3.3	11.3	13.0	B
Unbleached Scandinavian Mitscherlich	0.7	...	3.6	B	..	..
Bleached soda	0.6	1.2	4.3	B	..	..

B indicates blistering—test discontinued.

DISCUSSION OF DATA

Moisture Sorption

In Fig. 1 the moisture sorption of a southern kraft paper-base laminate is plotted as a function of immersion time. An examination of this curve shows that for all practical purposes moisture equilibrium has been attained in about 30 days. The scattering of the points indicates a degree of error of 0.5% (relative) at the longer immersion time and somewhat better agreement at the shorter immersion times. The lower curve in this figure illustrates the moisture sorption of a cast piece of the resin alone. The two curves are not exactly comparable because the resin sample was cast in a mold and slowly polymerized at 80°C. in order to obtain a piece free of bubbles and cracks.

Table II presents the data on moisture sorption for the eight paper fillers studied. These data illustrate the significant differences in a property as a function of the paper filler. Several of the most interesting observations to be gained from the data are these:

1. The less refined pulps, such as krafts and newsprint, have the least moisture sorption. This may be due to the action of noncellulosic constituents (lignins) on the phenolic resin to promote better flow and more uniform distribution of resin.

2. The positions of soft alpha and regular alpha papers are somewhat anomalous. Both of these papers exhibit a 24-hour sorption value of 1.6%; however, the regular alpha shows a final value 40% higher than the soft alpha. It may seem contradictory that alpha papers with such high sorption values are extensively used as fillers in electrical grade laminates. However, it must be remembered that the phenolic resins used in electrical laminates have a longer cure time and that resin contents of 50% are common.

Table IV. Average Edge Swelling of Paper Laminates, Total Immersion in Water at 25°C.

Filler type	Per cent thickness increase at edge					
	1 Day	2 Days	7 Days	30 Days	60 Days	90 Days
Southern kraft	1.6	2.0	3.3	3.9	4.1	3.9
Northern kraft	2.2	3.7	6.0	7.7	8.1	8.0
Newsprint broke	1.4	2.6	6.2	8.4	9.3	8.6
Soft alpha	2.6	3.4	5.1	7.3	9.8	10.6
Regular alpha	6.3	...	8.3	9.1	10.0	B
Bleached sulphite	6.0	...	9.0	11.0	11.5	11.6
Unbleached Scandinavian Mitscherlich	6.3	...	9.5	11.0	11.0	11.0
Bleached soda	2.6	3.2	6.5	12.2	12.5	B

B indicates blistering—test discontinued.

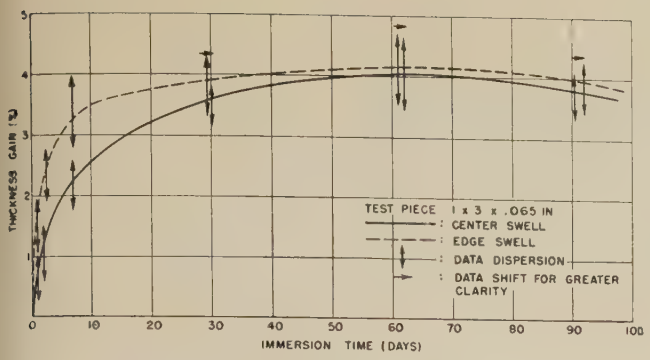

Fig. 2. Average moisture swelling of southern kraft base laminate at 25 °C.

3. Erroneous conclusions are possible if one accepts the 24-hour sorption value of a laminate rather than the saturation value. Thus soda pulp paper has a 24-hour value of 2.2% and a saturation figure of over 15% whereas southern kraft has values of 2.6 and 7.1% on a comparable basis.

4. It is apparent that not only the saturation values but the rates at which saturation is attained vary widely for the papers studied.

Center and Edge Swelling

Table III presents data concerning the amount of swelling in the center of the test piece as a function of the paper stock during a period of 90 days. In some cases the test was abandoned because of inaccuracy caused by the appearance of blisters. Table IV presents corresponding data for the swelling along the edge of the same specimens. Figure 2 illustrates the center and edge swelling curve for the southern kraft stock and includes the scattering of the data.

From the data several conclusions are apparent:

1. Southern kraft shows definite superiority over the other papers on the basis of both edge swelling and center swelling.

2. The expected difference between swelling along permeable edges and the less accessible center is maintained for at least a week, but at 30 days the swelling has become fairly well distributed over the piece and has practically reached a constant value.

Elongation of Laminates

Tables V and VI present data on elongation of samples on immersion and Fig. 3 illustrates the data

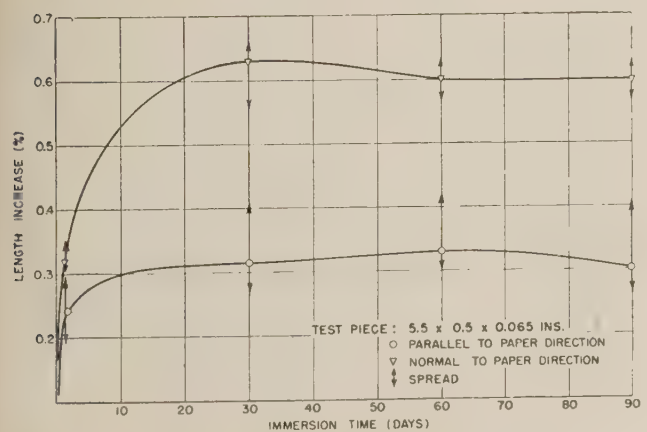

Fig. 3. Average elongation of southern kraft base laminate at 25 °C.

Table V. Average Elongation of Paper Laminates, with Grain Total Immersion in Water at 25°C.

Filler type	Average per cent elongation, parallel machine (with grain) 1 Day	2 Days	7 Days	30 Days	60 Days	90 Days
Southern kraft	0.17	0.24	..	0.32	0.33	0.31
Northern kraft	0.10	0.15	0.21	0.16	0.16	0.16
Newsprint broke	0.11	0.16	0.34	0.33	0.34	0.34
Soft alpha	0.19	0.31	0.43	0.41	0.42	0.40
Regular alpha	0.09	..	0.45	0.52	0.38	0.39
Bleached sulphite	0.07	..	0.22	0.31	0.28	0.26
Unbleached Scandinavian Mitscherlich	0.07	..	0.21	0.24	0.22	0.23
Bleached soda	0.16	0.24	0.35	0.28	0.29	0.29

dispersion of the southern kraft filled board. Although the original intent of the project was to prepare grainless papers, that is, with properties equal in both directions, properties both parallel and normal to machine direction were determined. It will be seen from the following data, and in a subsequent paper (*3*) that, in spite of efforts to the contrary, variation as a function of direction is significant. Table V shows data on samples which were cut parallel to the machine direction (with grain), and Table VI shows data on samples which were cut normal to the machine direction (cross grain).

Table VI. Average Elongation of Paper Laminates, Cross Grain Total Immersion in Water at 25°C.

Filler Type	Average per cent elongation, perpendicular to machine (cross grain) 1 Day	2 Days	7 Days	30 Days	60 Days	90 Days
Southern kraft	0.21	0.32	..	0.63	0.60	0.60
Northern kraft	0.19	0.28	0.46	0.48	0.49	0.46
Newsprint broke	0.15	0.23	0.50	0.64	0.65	0.64
Soft alpha	0.29	0.46	0.70	0.72	0.73	0.69
Regular alpha	0.17	..	0.91	1.02	1.01	1.00
Bleached sulphite	0.10	..	0.42	0.63	0.63	0.58
Unbleached Scandinavian Mitscherlich	0.12	.	0.41	0.57	0.59	0.54
Bleached soda	0.23	0.37	0.66	0.64	0.64	0.63

From the data several interesting observations are evident.

1. On the basis of growth parallel to the grain most of the papers are in the same range with northern kraft showing best properties.

2. Cross-grain growth, however, is from two to three times as great as parallel growth.

3. Unbleached Scandinavian Mitscherlich and northern kraft are best on the basis of uniformity in both directions and over-all low elongation.

4. Thirty days appears to be an adequate test period.

CONCLUSIONS

On the basis of the data it appears that most samples had reached equilibrium in all three properties in about 30 days, with the exception of the two alpha papers on moisture sorption and increase in thickness. The superiority of southern kraft and northern kraft in most properties tested is quite apparent and explains the wide use of these stocks in general purpose paper laminates.

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Bark Volume in Cordwood

EVERETT B. CHAMBERLAIN and H. ARTHUR MEYER

A simple procedure is given for the calculation of bark volume in cordwood on the basis of average bark thickness measured with bark gages.

It is a well-known fact that bark makes up a considerable portion of the total volume of rough or unpeeled wood. It is likewise known that bark volume in per cent of total unpeeled volume varies considerably from one species to another and within species from one locality to another. The relative amount of bark volume in cordwood depends on average bark thickness which can easily be determined with the help of the Swedish bark gage. The amount of bark volume corresponding to the bark thickness determined with a bark gage is not, however, equal to the actual difference in the volume of a pile of wood before and after peeling. The measurements made with a bark gage always give maximum bark thickness, and not bark thickness measured in the bark fissures. On the other hand, in a pile of unpeeled wood, the narrower ridges of one bolt will tend to fit into the wider fissures of another bolt. The actual bark volume of stacked cords is therefore smaller than the calculated bark volume based on average bark thickness measured with a bark gage.

In a recent investigation by the Department of Forestry of the Pennsylvania State College, a simple procedure was established which permits the calculation of bark volume in cordwood on the basis of average bark thickness measured with a bark gage. All that is necessary is to determine the average ratio between the diameter inside bark d and the diameter outside bark D of a number of bolts of the species to be worked up into pulpwood or cordwood. The average value of the ratio

$$k = \frac{d}{D}$$

is best determined by dividing the sum of about 20 inside bark measurements by the sum of the corresponding outside bark measurements; expressed in symbols, this means that we compute

$$k = \frac{\Sigma d}{\Sigma D} = \frac{\Sigma D - \Sigma 2B}{\Sigma D},$$

where $\Sigma 2B$ signifies the sum of the measured double bark thicknesses. The bark volume in per cent of unpeeled wood is then given by the simple formula

$$\text{Bark volume per cent} = BV(\%) = 80\,(1 - k^2).$$

The factor 80 which accounts for the fact that the ridges and fissures of bolts will, to a certain extent, fit into each other, was determined experimentally as explained below. The formula for computing bark volume without this factor has been published earlier (*1*). By way of an example, the ratio k for black cherry, calculated on the basis of 27 bark measurements was found to be equal to

$$k = \frac{203.9 - 18.64}{203.9} = 0.909.$$

Bark volume in per cent of rough wood for black cherry in central Pennsylvania (College farm woodlands), is therefore equal to

$$BV(\%) = 80\,(1 - 0.909^2) = 13.9\%.$$

The basic work of this study (*2*) consisted in the measurement of 30 piles of pulpwood before and after peeling. These piles, which contained about one half a cord each, were carefully built so as to avoid unnecessary holes or air spaces between the unsplit bolts. Bolts with excessive crook, sweep, or butt flare were not used and all knots were trimmed as closely as practicable. Heights of piles of unpeeled wood were obtained by taking at least four height measurements per pile. The piles were then torn down to be peeled. As the sticks were removed the diameter outside bark of each one was measured at the midpoint, taking the average of two measurements made at right angles with a standard caliper. In addition, double bark thickness was taken on at least 20 sticks

Fig. 1. A cord of pulp wood of black cherry before and after peeling

Everett B. Chamberlain and H. Arthur Meyer. Department of Forestry, the Pennsylvania State College, State College, Pa. Authorized for publication on May 12, 1950 as Paper No. 1599 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

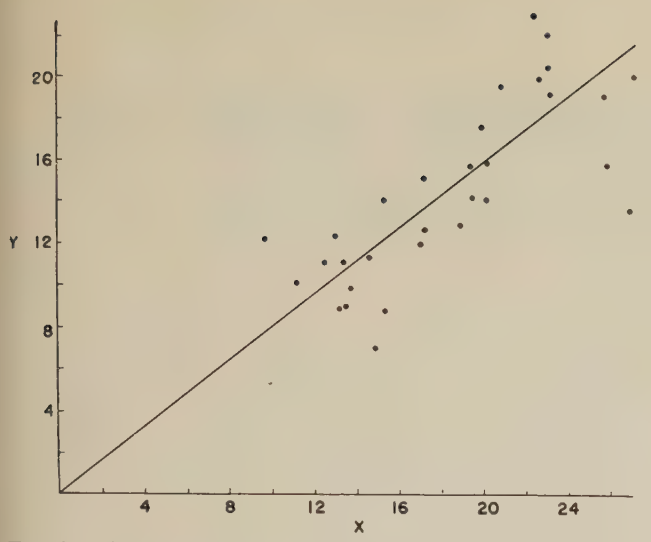

Fig. 2. Actual bark volume expressed in per cent of unpeeled wood (Y) plotted against uncorrected calculated bark volume percentages (X)

in each pile, care being taken to distribute these measurements through all diameter classes. As soon as these measurements were completed the wood was peeled and restacked. Average pile height was then determined as before. A photograph showing the same pile of wood before and after peeling is given in Fig. 1.

Having the dimensions of each pile in both rough and peeled wood, it was a simple matter to compute actual bark volume and bark volume in per cent of unpeeled wood. From the bark thickness data obtained for each pile, bark volume was then calculated as follows:

Volume of bolt of length L with bark $= V = \frac{\pi}{4} \cdot D^2 \cdot L$

Table I. Experimental Data Relating to Bark Thickness and Bark Volume Obtained for 30 Piles of Pulpwood

Pile No.	*Species*	*Actual bark volume in per cent of volume with bark, %*	*Ratio of diameter outside bark to diameter inside bark* (k)	*Bark volume calculated but not adjusted,*[a] *%*
1	Black cherry	12.3	0.910	17.2
2	Black cherry	16.1	0.906	18.6
3	Black cherry	15.5	0.909	17.4
4	Red maple	11.3	0.933	13.0
5	Red maple	12.6	0.932	13.1
6	Red maple	8.9	0.920	15.4
7	Red maple	14.5	0.920	15.4
8	Red maple	7.2	0.922	15.0
9	White oak	20.5	0.857	26.6
10	White oak	19.5	0.866	25.0
11	White oak	19.6	0.875	23.4
12	White oak	14.0	0.859	26.2
13	White oak	19.9	0.889	21.0
14	White oak	23.4	0.879	22.7
15	Scarlet oak	14.5	0.896	19.7
16	Scarlet oak	20.9	0.876	23.3
17	Scarlet oak	14.3	0.893	20.3
18	Black cherry	16.2	0.892	20.4
19	Black oak	22.5	0.876	23.3
20	Black oak	17.1	0.865	25.2
21	Aspen	20.3	0.878	22.9
22	Red pine	16.1	0.894	20.1
23	Red pine	13.3	0.897	19.5
24	Virginia pine	10.3	0.943	11.3
25	Virginia pine	12.5	0.950	9.8
26	Balsam fir	13.1	0.923	14.8
27	Balsam fir	9.2	0.930	13.5
28	Balsam fir	9.1	0.931	13.3
29	Balsam fir	11.3	0.930	13.5
30	Balsam fir	10.1	0.928	13.9

[a] In order to obtain actual bark volume in cordwood, these values must be multiplied by the factor 0.80. The correction factor varies considerably from one pile to another due to differences in piling. Although one single factor has been calculated for the various species listed above, it is entirely possible that from a larger body of data, significantly different factors might be obtained for different species or groups of species.

Table II. Bark Volume in Cordwood in Per Cent of Unpeeled Wood for Different Average Values of the Ratio (k) of Diameter Outside Bark to Diameter Inside Bark

Ratio (k)	*Bark volume in per cent of unpeeled wood*[a]
0.85	22.2
0.86	20.8
0.87	19.4
0.88	18.0
0.89	16.6
0.90	15.2
0.91	13.8
0.92	12.3
0.93	10.8
0.94	9.3
0.95	7.8

[a] Computed by formula $80(1 - k^2)$.

Volume of bolt of length L without bark $= v = \frac{\pi}{4} \cdot d^2 \cdot L = \frac{\pi}{4}(kD)^2 \cdot L$

Bark volume $= V - v = V - k^2V = V(1 - k^2)$

Bark volume calculated, per cent $= \frac{V(1 - k^2)}{V} 0.100 = (1 - k^2)\, 0.100$

Since the same ratio k is applied to bolts of different diameters, the formula for the calculation of bark volume in per cent of rough volume is applicable to entire stacks of cordwood. However, as previously explained, bark volume calculated in this manner will be too high. This is well substantiated when comparing the calculated bark volume percentages with the actual bark volume percentages listed in Table I. In Fig. 2 the actual bark volumes of each stack are plotted against the calculated and uncorrected bark volumes. A straight line $Y = b \cdot X$ fitted to the data expresses adequately the relationship between actual and calculated bark volume. The constant b has been determined by the method of least squares ($b = \Sigma XY / \Sigma X^2$), obtaining a value for b equal to 0.80. With this correction factor it is possible to determine bark volume in cordwood as soon as the average ratio k between diameter inside bark to diameter outside bark has been determined. The measurements of double bark thickness on about 20 bolts suffice for the determination of k.

It is not possible to list here average values of k for different species which would be applicable over a wide area since for one and the same species these values vary from one locality and site class to another. In order to convey an idea of the range of values for the ratio k, the following data obtained in Pennsylvania are given:

White pine	0.89–0.91
Hemlock	0.89–0.91
White oak	0.87–0.93
Black oak	0.86–0.88
Red oak and scarlet oak	0.88–0.92
Chestnut oak	0.84–0.88
Black cherry	0.89–0.91
Red maple	0.92–0.94

Table II contains a series of values for bark volume in per cent of unpeeled wood corresponding to gradually differing average values of the ratio k of diameter outside bark to diameter inside bark.

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Effect of Bark in the Neutral Sulphite Semichemical Pulping of Aspen, Hickory, and Slash Pine

E. L. KELLER

Bark-free chips and mixtures of chips with up to 25% of bark by weight were pulped by the neutral sulphite semichemical process. With yields from the wood fiber in the 76 to 80% range, the yields from the bark were calculated to be 56, 52, and 35% for quaking aspen (*Populus tremuloides*), pignut hickory (*Carya glabra*), and slash pine (*Pinus caribaea*), respectively. The yield from the hickory bark was verified experimentally. During the impregnation stage of the digestions, slash pine bark absorbed twice as much sodium sulphite from the cooking liquor as was absorbed by an equal weight of wood; while aspen bark took up only slightly more than the corresponding wood, and hickory bark an intermediate amount. The inclusion of bark in amounts equivalent to the use of unpeeled wood required only slight changes in cooking conditions. With the exception of an increase in the folding endurance of the hickory pulps, the strength of standard test sheets decreased regularly with increasing amounts of bark. Folding strength was the most sensitive of the strength properties, the loss being 90% in one instance. Tearing resistance was least affected, with a maximum loss of 15%. The density of test sheets containing bark was low. The properties of the hickory pulps were little affected by the presence of bark; while aspen pulps lost seriously in strength and density. Slash pine bark had an intermediate effect.

UNPEELED or partially peeled wood is sometimes pulped by the neutral sulphite semichemical process. The chief objections to this practice are the likelihood of increased consumption of chemicals and of lowered strength in the finished product. For some purposes, the presence in the pulp of numerous dark particles derived from the outer bark is highly objectionable; but for such products as fiberboards, the elimination of the difficult and costly peeling of the hardwoods commonly pulped by this process may be more than sufficient compensation. Since very little specific information is available on the effects of pulping bark by this process, the present investigation was undertaken to evaluate these effects for several representative species.

Extremely low pulp yields have been obtained from bark cooked by the alkaline processes. The extensive solubility of barks in caustic soda, reported by many investigators (*8*), suggests the possibility of obtaining much larger yields by the neutral sulphite semichemical process since the superiority of this process in retaining the lower carbohydrates has been amply demonstrated in the pulping of wood. However, the large amount of material soluble in hot water, which is also characteristic of many barks, severely limits the maximum yield obtainable under ideal conditions. The relative values can be illustrated from the data of Hossfeld (*6*), who obtained a yield of 43% from aspen bark cooked with sodium sulphite under conditions that would have yielded 80% if they had been applied to wood. The same cooking conditions as to time and temperature, but with the sodium sulphite replaced with sodium hydroxide, gave a yield of only 26%. These two experimental yield figures, however, are not entirely comparable since the normal pulping reactions proceed more rapidly in a very alkaline than in a neutral medium.

Data on the papermaking qualities of bark cooked by the neutral processes are lacking. Aries (*1*) found that the use of peeled or unpeeled wood made no substantial difference in the properties of corrugating boards that were prepared from a mixture of dense hardwoods pulped to 70% yield by the neutral sulphite process. Obviously the size and structure of the various elements that form the bark govern its value in the pulp. The longer cells (phloem fibers, sieve cells, and sieve-tube elements) appear to be promising papermaking material. The other cells, such as the parenchyma and stone cells, may show high losses in the handling of the pulp because of their small size. The short cells that do remain in the pulp may lower the strength of the product insofar as they behave as an inert filler and interfere with the normal fiber-to-fiber bonding of the long units. The proportion of long to short elements, and the nature of each, varies considerably among the species. Eames and MacDaniels (*5*) report that in the gymnosperms the parenchyma are relatively few compared with the number of sieve cells, and among the angiosperms the ratio of parenchyma to sieve-tube elements is unusually low in hickory. Hossfeld (*6*) has briefly summarized the work of Kaufert (*7*) on the morphology of aspen bark, and that of Wangerin (*12*) on its chemical composition.

A difference in the pulping characteristics of inner and outer barks would be expected because of the changes that take place when the inner bark stops functioning as an active part of the vascular system. Rioux (*10*) pulped spruce bark by the acid sulphite process and found that the outer bark could not be cooked and was not bleachable by the standard procedures, whereas the inner bark of freshly cut wood was cooked to a good light-colored fiber. Hossfeld (*6*) commented that the outer bark, after neutral sulphite cooking, was retained in a shredded and unpulped state.

DESCRIPTION OF MATERIAL

The aspen pulpwood was obtained from northern Wisconsin, while the hickory was received as split logs from the vicinity of Asheville, N. C., and the slash pine was shipped from stands near Bogalusa, La. Data on the pertinent physical properties of the three shipments are summarized in Table I.

The aspen bark was typically young, thin, and pli-

E. L. KELLER, Chemical Engineer, Forest Products Laboratory, maintained at Madison Wis., in cooperation with the University of Wisconsin, Forest Service, U. S. Department of Agriculture.

Table I. Physical Characteristics of Woods Pulped with and without Bark

Species	Shipment number	Age, yr.	Diameter, in.	Growth rate (xylem), rings per in.	Bark thickness, in.
Aspen	2811	23	5.0	4.7	0.13
Pignut hickory	2740	245	24.0	20.0	0.75
Slash pine	2847	10	5.5	3.6	0.19

able. Since this fast-growing species is usually cut for pulpwood while still young, the bark is more likely to retain traces of the original cortical matter at the time of felling than is the case with slower growing species. The fibrous structure of the inner bark was very evident beneath the outermost layer of phloem. Decomposition of the bark with sodium chlorate and nitric acid disclosed that the long units consisted of phloem fibers and sieve-tube elements.

The hickory bark was characterized by high density and toughness. It contained very large numbers of thick-walled phloem fibers which averaged 1.3 mm. in length and closely resembled the corresponding xylem fibers. The sieve-tube elements were typically thin-walled and fragile and were far less numerous than the fibers.

The slash pine bark represented those species in which phloem fibers are lacking. Beneath the brittle outer bark, which was present as the characteristic large scales, the structure was not so conspicuously fibrous as were the aspen and hickory barks. The long elements consisted exclusively of sieve cells which resembled thin-walled tracheids in size and shape. The longer elements in both the pine and aspen barks were approximately of the same length as the corresponding structures in the woods.

EXPERIMENTAL WORK

To prepare the bark and wood for pulping, the rough wood was carefully hand-peeled to remove as much of the inner bark as possible. The clean bolts were converted to $^5/_8$-inch chips with a small commercial chipper; the bark was reduced to pieces of approximately the same size with a hatchet. Both wood and bark were stored for a short time before use. The two components were subsequently recombined in the desired proportions for each digestion.

The pulping conditions for each species were selected so that the bark-free chips would give a yield of from 75 to 80%. Mixtures of chips and bark containing 6, 12, and 25% by weight of bark (on a moisture-free basis) were then pulped under these same conditions, except for a slight shortening of the cooking time in some instances to take care of a more rapid exhaustion of the chemicals. Digestions were made in duplicate.

The digestion schedule included the following stages: (1) steaming of the chips for $^1/_2$ hour at atmospheric pressure; (2) impregnation with the cooking liquor for 1 hour at 120°C., followed by removal of all the free liquor in the digester; and (3) cooking at 170°C. until the concentration of sodium sulphite in the liquor was reduced to 10 grams per liter. These operations were conducted in a stainless steel tumbling digester of 0.8 cubic foot capacity. Except for the initial steaming of the dry chips and the heating of the digester contents from 120 to 170°C., in which direct steam was used, heat was furnished by a steam jacket surrounding the main body of the digester. The cooking conditions are given in Table II.

The cooked material, which remained in its original form at these high yields, was fiberized by passing it through a single-rotating-disk attrition mill. The pulp and water from the mill were caught in a box fitted with a 65-mesh screen. Whatever fine material passed through the meshes before a filter pad of pulp accumulated was lost. Although the amount of this loss was not determined, it was believed to approximate roughly the shrinkage which would be found in commercial operation. After the fiberized pulp had been washed, the excess water was pressed out and the pulp cake broken up, weighed, and sampled for moisture and determination of the yield.

Pulp Tests

The evaluation of the physical and chemical properties of the pulps conformed with the TAPPI standard methods (*11*), except for the determination of holocellulose (*2*) and the preparation of the test sheets made from the hickory and slash pine pulps. These test sheets were formed on a 7 by 9-inch mold fitted with 100-mesh wire and pressed between blotters at 50 p.s.i. Subsequent tests (not reported here) showed that this method of sheet preparation gave test sheets which were comparable, in this instance, with sheets formed by TAPPI methods used in preparing the aspen sheets.

DISCUSSION OF RESULTS

All three species showed decreasing yields of pulp and slight increases in the rate of chemical consumption as bark was substituted for wood (Table II). When

Table II. Impregnation and Cooking Conditions for Semichemical Pulping of Three Species of Wood and Wood-bark Mixtures

Species	Digestion No.	Mixture charged		Liquor charged		Chemical retained		Cooking time at 170°C.		Na_2SO_3 content of spent liquor, g./l.	Pulp yield,[a] lb.
		Wood, %	Bark, %	Na_2SO_3, g./l.	$NaHCO_3$, g./l.	Na_2SO_3 Lb./100 lb. wood and bark	$NaHCO_3$ lb./100 lb. wood and bark	hr.	min.		
Aspen	790–97	100	0	85.3	34.3	14.4	8.9	1	45	11.9	75.3
Aspen	830–31	94	6	85.0	34.3	14.0	8.6	1	45	10.4	74.6
Aspen	832–33	88	12	85.2	34.2	13.7	8.1	1	40	9.1	73.5
Aspen	798–99	75	25	85.0	34.0	14.1	8.0	1	30	10.7	71.2
Pignut hickory	759–96	100	0	138.5	54.2	11.0	6.7	1	30	8.8	76.7
Pignut hickory	788–89	94	6	138.5	53.8	11.8	7.1	1	30	9.1	76.3
Pignut hickory	766–67	88	12	138.3	54.2	12.6	7.1	1	20	10.7	74.2
Pignut hickory	764–65	75	25	138.6	54.4	13.4	7.1	1	15	11.0	71.3
Pignut hickory	768	0	100	140.0	54.5	17.4	7.3		45	11.3	52.4
Slash pine	834–37	100	0	120.7	48.5	16.4	6.9	4	00	10.6	78.7
Slash pine	841–42	94	6	120.0	47.5	17.5	7.1	4	00	11.7	75.4
Slash pine	839–40	88	12	120.3	48.5	18.1	7.5	3	50	13.6	73.7
Slash pine	836–38	75	25	120.0	49.5	20.0	7.5	3	30	12.3	68.6

[a] Per 100 pounds of material charged.

Table III. Chemical Composition of Semichemical Pulps from Three Species of Wood and Wood-bark Mixtures

Species	Digestion No.	Mixture pulped: Wood, %	Mixture pulped: Bark, %	Lignin, %	Holocellulose, %	Alpha-cellulose, %	Pentosans, %	Ash, %
Aspen	790–97	100	0	10.3	84.5	63.1	18.4	1.3
Aspen	830–31	94	6	11.0	82.5	62.1	17.9	1.5
Aspen	832–33	88	12	12.3	82.0	63.0	17.8	1.9
Aspen	798–99	75	25	13.2	82.0	62.1	18.1	2.6
Pignut hickory	759–96	100	0	15.6	77.5	58.2	18.6	1.6
Pignut hickory	766–67	88	12	17.5	74.9	56.9	18.1	2.5
Pignut hickory	764–65	75	25	18.1	72.7	55.4	16.6	3.4
Slash pine	834–37	100	0	22.0	74.5	58.7	9.2	2.2
Slash pine	841–42	94	6	22.3	75.1	57.6	8.7	2.2
Slash pine	839–40	88	12	22.5	74.1	56.1	8.6	2.3
Slash pine	836–38	75	25	23.9	73.3	56.1	8.5	2.6

25% of the wood was replaced with bark, the decrease in yield was 5% of the total material charged in the case of aspen, 4% in the case of hickory, and 10% with pine. The yield of cooked material from the bark, in terms of the weight of bark originally charged, was estimated from this shrinkage in over-all yield. In making the calculations, the yield from the wood was assumed to be 1% greater than that obtained when cooking the bark-free wood because of the shortened cooking time. On this basis, yields of 56, 52, and 35% were obtained from aspen, hickory, and pine barks, respectively. The estimated yield of 52% from hickory bark agreed with the 52.4% obtained experimentally (digestion 768y, Table II).

To compare the pulping rates of aspen bark and aspen wood, the two materials were cooked separately for varying lengths of time. The yields from the wood were varied from 80 to 68% in order to approximate the normal range of semichemical pulping. When these cooking conditions were applied to the bark, the corresponding yields were 62 to 50%. The large difference between the yields from the two materials under conditions of minimum pulping reflects the comparatively high content of hot-water-soluble compounds characteristic of barks. A solubility in hot water of 23% has been reported for aspen bark (*12*). The fact that the difference of 18 points between the two groups of yield figures remained constant as the cooking was extended showed that once the initial water-soluble material had been removed, the residue from the bark was solubilized at a somewhat greater rate than the wood.

In spite of the extensive solubility of barks in caustic soda, it was believed that the normal variation in the alkalinity of commercial neutral sulphite semichemical liquors was insufficient to influence the yield. Some confirmation of this was obtained by successive digestions of hickory bark in which the yields were found to be identical, even though the cooking liquors had been adjusted to give pH values of 6.9 and 7.8 in the spent liquors.

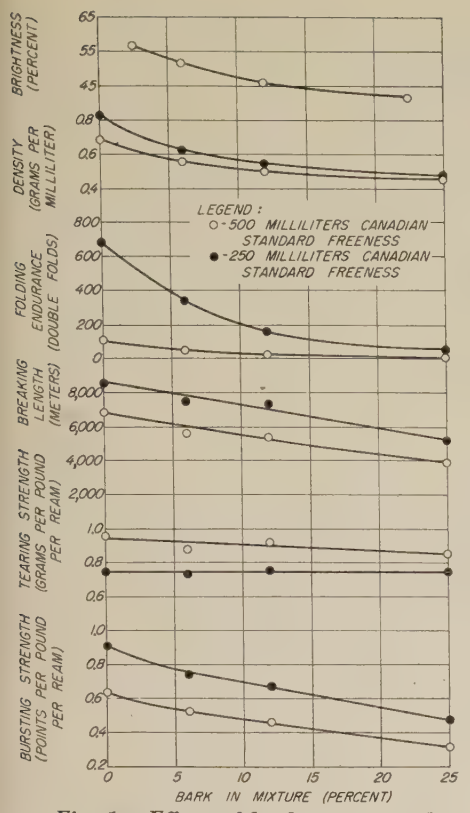
The slash pine bark, which gave the lowest yield, absorbed the largest amount of sodium sulphite during the impregnation. Since the normal cooking reactions proceed very slowly at the impregnation temperature of 120°C., the increased absorption may have been mechanical due to a higher void volume in the bark than in the wood; or possibly chemical, due to the presence of a readily reducible substance among the extraneous matters. The evidence from the volumes of free liquor at the end of the impregnation and from the concentrations of sodium sulphite in the liquors, suggests that both mechanisms were involved. A calculation of the amounts of sodium sulphite absorbed by the slash pine bark and chips gave values of 30 and 16.4% on a weight basis, respectively. The hickory bark had a slightly greater specific absorption than the wood; no significant difference was shown between bark and wood in the case of aspen.

The species also differed in the effect of the bark on the amount of sodium bicarbonate neutralized and absorbed during the impregnation stage. The quantity decreased with increasing ratios of aspen bark, but increased with increasing amounts of hickory and pine barks. Since no change was found in the amount of sodium sulphite absorbed as the proportion of aspen bark was increased it is likely that this decrease in the amount of bicarbonate represents an actual difference in the amount neutralized rather than a difference between wood and bark in void volume. Some pH values on liquors at the end of the impregnation stage on similar digestions, using bark-free aspen and mixtures containing 25% of bark, also indicated a slight decrease in actual neutralization (pH 7.3 and 7.5, respectively).

The strength properties of the pulps decreased as the amount of bark increased (Figs. 1, 2, and 3). The sole exception was the folding endurance of the hickory pulps which improved substantially. In general, folding strength was the most sensitive to the presence of bark. The breaking length and bursting strength showed less influence, and tearing resistance was little affected. Test sheets made from pulps containing bark had lower apparent densities than bark-free sheets, and the density increased at an abnormally slow rate when the pulp was processed further in the beater.

These observations apply to test sheets prepared from pulps beaten to the same freeness and wet pressed under the same conditions. Two characteristics of the cooked bark, however, modified the normal relationship between the degree of processing, as measured by freeness, and the strength and density of the test sheets. One characteristic was the large quantity of fine material derived from the bark; the other was the large size of many of the bark particles which caused them to protrude above the surface of the sheets. A high concentration of fines would reduce the freeness values, and the surface irregularities of the sheets would cause low apparent densities as calculated from the weight and thickness measurements.

It was observed that large quantities of parenchymatous cells were discharged from the attrition mill in the form of clumps, and that these were subsequently broken down into smaller groups and individual cells in the beater. Morris and deMontigny (*9*) found that even though the fines in a wood pulp may have little effect on the strength, the ray cells and debris do influence the freeness. An effect similar to this,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FOLDING ENDURANCE (DOUBLE FOLDS)
BREAKING LENGTH (METERS)
TEARING STRENGTH (GRAMS PER POUND PER REAM)
BURSTING STRENGTH (POINTS PER POUND PER REAM)
LEGEND :
○-500 MILLILITERS CANADIAN STANDARD FREENESS
●-250 MILLILITERS CANADIAN STANDARD FREENESS
BARK IN MIXTURE (PERCENT)

Fig. 1. Effect of bark on strength properties and brightness of aspen pulp at two freeness values

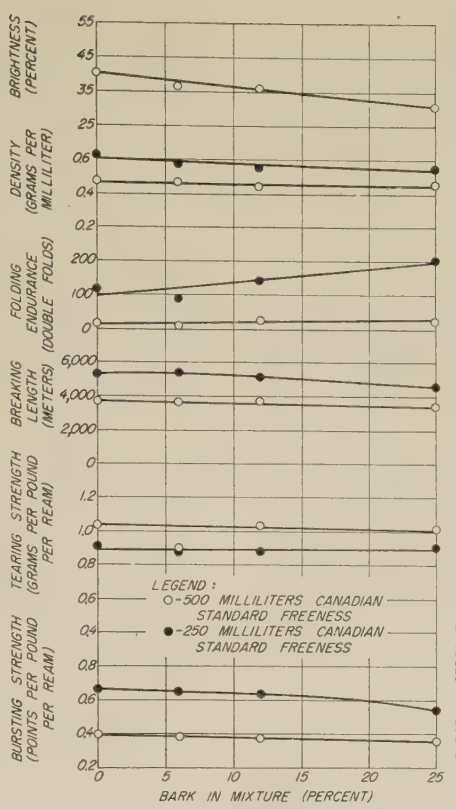
BRIGHTNESS (PERCENT)
DENSITY (GRAMS PER MILLILITER)
FOLDING ENDURANCE (DOUBLE FOLDS)
BREAKING LENGTH (METERS)
TEARING STRENGTH (GRAMS PER POUND PER REAM)
BURSTING STRENGTH (POINTS PER POUND PER REAM)
LEGEND :
○-500 MILLILITERS CANADIAN STANDARD FREENESS
●-250 MILLILITERS CANADIAN STANDARD FREENESS
BARK IN MIXTURE (PERCENT)

Fig. 2. Effect of bark on strength properties and brightness of hickory pulp at two freeness values

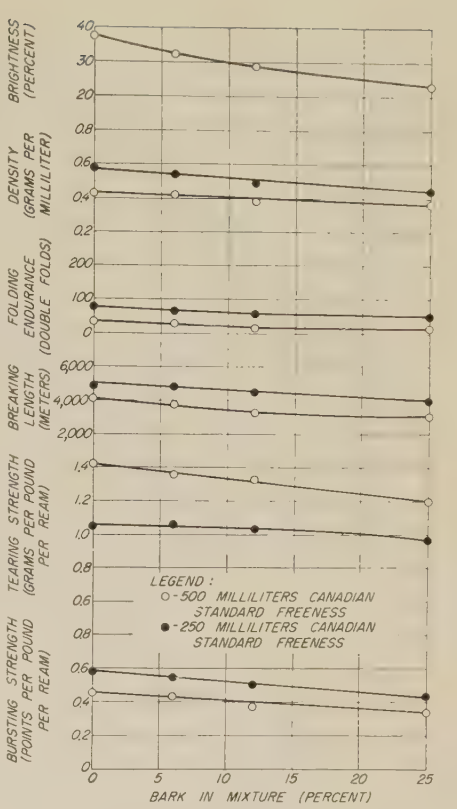
BRIGHTNESS (PERCENT)
DENSITY (GRAMS PER MILLILITER)
FOLDING ENDURANCE (DOUBLE FOLDS)
BREAKING LENGTH (METERS)
TEARING STRENGTH (GRAMS PER POUND PER REAM)
BURSTING STRENGTH (POINTS PER POUND PER REAM)
LEGEND :
○-500 MILLILITERS CANADIAN STANDARD FREENESS
●-250 MILLILITERS CANADIAN STANDARD FREENESS
BARK IN MIXTURE (PERCENT)

Fig. 3. Effect of bark on strength properties and brightness of slash pine pulp at two freeness values

due to the presence of fines derived from the bark, would have meant that when strength values were compared at equal freenesses, the pulps containing bark had been processed less than the corresponding bark-free pulps. In making comparisons under such conditions the curtailed hydration would exaggerate the apparent effect of the bark on strength.

In the aspen series, such a phenomenon was indicated by a steady decrease in the beating time required to reduce the freeness from 500 to 250 ml. as the percentage of bark was increased. The beating time was reduced by one-fourth when the maximum amount of bark was present. In order to estimate the significance of this in the strength comparisons, the time required to beat this pulp to 250 ml. freeness, and the corresponding strength data, were taken from the beating curves and compared with the strength of a bark-free pulp beaten for the same number of minutes. The figures indicated that the strength losses attributed to the bark had been exaggerated by approximately one seventh in the case of the aspen bark. The hickory and pine pulps showed no shortening of the beating time.

The differences in the characteristics of the three barks were reflected in the properties of the pulps. The effects of the different barks in decreasing the apparent densities of the test sheets were in the same order as the respective losses in strength, which suggests a close correlation between these strength losses and the decrease in the number of fiber-to-fiber bonds consequent to a looser sheet structure. Aspen bark had the most deleterious effect on strength (Fig. 1). At 250-ml. freeness, the folding strength of pulp with 25% bark decreased 90%, bursting strength and breaking length declined about 45%, and tearing resistance was unchanged in comparison with bark-free pulp. With the maximum amount of bark present, the density at 500-ml. freeness was only two thirds that of the bark-free sheets; and on further beating to 250 freeness, the density increased by only 0.02 gram per ml., compared with 0.14 in the bark-free sheets.

A brief supplementary investigation was made to determine whether the large size of the bark fragments was responsible for the stabilizing effect of the aspen bark on the density. Two lots of cooked chips, one prepared from bark-free chips and the other from a mixture containing 25% of bark, were fiberized after the attrition mill had been equipped with a different type of plates. Although the bark particles were appreciably smaller than they had been in the pulps from the first series of digestions, the density phenomena were unaffected.

Hickory bark had the least adverse effect on pulp strength. This was probably due to the large proportion of fibers in the bark. At 500 freeness the strength losses were almost insignificant, even with large amounts of bark. At the lower freeness of 250, the losses were greater, but still not extreme (Fig. 2). An explanation of the improvement in folding endurance as the proportion of bark was increased will have to await more information on the properties of hickory bark fibers and their effect on sheet characteristics. Oddly enough, a pulp prepared entirely from bark had practically no folding endurance. Hickory bark affected the density of the test sheets much less than did aspen bark.

The slash pine bark was intermediate in its effect on pulp strength when comparison was made on the basis of equal proportions of bark in the mixtures charged to the digesters (Fig. 3). However, if adjustment is

made for the lower yield obtained from the pine bark (35% from pine bark, compared with 52% from aspen bark), the effect of a pound of cooked pine bark in the pulp was approximately equal to that of a pound of cooked aspen bark. Calculation of the percentage losses in the various properties showed the decrease in tearing strength to be disproportionately high in comparison with the corresponding losses in the aspen series. This can be attributed to the preponderance of thin-walled sieve cells in the pine bark, in contrast to the thick-walled phloem fibers characteristic of the other two species. Pulps from thin-walled springwood xylem elements have been reported to be unduly low in tearing resistance in comparison with similar pulps from thick-walled summerwood (*3*).

In appraising the comparative value of barks, consideration should also be given to the absolute strengths of the pulps. For example, the slash pine pulp containing the maximum amount of bark was superior in tearing strength to bark-free hickory; and, although the aspen pulp prepared from 25% bark had suffered severe strength losses, it was fully equal to bark-free hickory and pine pulps in breaking length.

The chemical properties of the pulps were little changed by the substitution of bark (Table III). As the ratio of wood was reduced the lignin content of the pulps increased, while the holocellulose decreased, and the fraction yielding furfural on hydrolysis fell off slightly. The maximum loss in alpha-cellulose was 3 points. Although there is considerable overlapping of the various fractions when raw barks are analyzed by the methods developed for wood (*8*), the sum of the ash, holocellulose, and lignin varied by only 1 or 2% in any one series of pulps. The high content of inorganic matter characteristic of many barks is reflected in the ash contents of the pulps. A good share of the salts are not leached out in the cooking.

Ether-solubility determinations for a few of the slash pine pulps showed little deviation from an average of 0.5%. Air drying and storage of the barks and chips before use may have contributed to this uniformity. Clermont and Schwartz (*4*) reported ether solubilities in excess of 20% in spruce and balsam barks, although the amount found appears to vary considerably. Such high values suggest the possibility of pitch troubles with some species. It has not been established, however, that ether solubility and pitch troubles correlate as well for barks as they do for woods.

The neutral sulphite semichemical process was not effective in decoloring the outer bark, which showed up in the pulps as a horde of dark fragments. Much, if not all, of the inner bark appeared to have retained its light color and blended indistinguishably with the rest of the pulp. Brightness values (Figs. 1, 2, and 3) showed considerable decrease, even with the smallest amounts of bark. The large number of colored and color-producing compounds often found among the extraneous materials in barks may have contributed to the general loss in brightness.

It was found, on the one instance investigated, that the normal decrease in brightness of pulps when beaten was reduced by the presence of cooked bark. Bark-free aspen pulp suffered an 8-point decrease in brightness when its freeness was lowered from 500 to 250 ml.; aspen pulp from a 25% bark mixture showed a corresponding drop of only 5 to 6 points. Because the bark particles were reduced in size by the beater, the increased specific area might be expected to accentuate the darkening of the sheet. Apparently, however, this effect was overcompensated by the difference between the two pulps in the effect of beating on sheet density with its attendant effect on the optical properties, and by greater effectiveness of the wood fibers in covering the particles of bark as they became smaller. Since the appearance of the bark was less objectionable when it had been reduced to minute fragments, it would seem desirable to adjust the processing conditions to obtain the greatest possible reduction in size for a given decrease in freeness.

CONCLUSIONS

Considerable variation was found between the barks of different species in (1) the yield of cooked residue from the bark, (2) the amount of chemical taken up during the impregnation stage of the digestion, (3) the decrease in density of test sheets prepared from the pulps, and (4) the strength of the product. The outer bark appeared in the pulp as prominent dark specks, whereas the inner bark remained light in color and merged with the wood fibers.

The results were consistent with the hypothesis that strength losses would be least with barks that contained a large proportion of fiber; and that the presence of large amounts of long sieve cells would compensate, to some degree, for an absence of phloem fiber. Hickory, which contains large amounts of phloem fibers, showed little loss in pulp strength attributable to the bark, whereas aspen, the bark of which contained fewer fibers, had marked losses and slash pine, which contains large quantities of long sieve cells instead of phloem fibers, showed intermediate losses in pulp strength.

Where the appearance of the product is not important, considerable bark from selected species of wood can be profitably included in the digester charge when pulping by the neutral sulphite semichemical process. The cooking conditions will require little, if any, adjustment.

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ASSOCIATION NEWS AND EVENTS

Report of Nominating Committee

The TAPPI 1951 Nominating Committee, consisting of G. W. E. Nicholson, Chairman, C. M. Conner, R. H. Hurst, J. L. Parsons, and R. M. True have presented the following nominees for officers and executive committeemen to be voted on by the membership prior to the TAPPI annual meeting in 1951.

President (one year): Kenneth P. Geohegan, Howard Paper Mills, Inc., Dayton, Ohio
Vice-President (one year): George H. Pringle, Mead Corp., Chillicothe, Ohio
Executive Committeemen (three years)
Ward D. Harrison, Reigel Paper Corp., Milford, N. J.
William F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Walter F. Holzer, Crown Zellerbach Corp., Camas, Wash.
Richard P. Price, Hammermill Paper Co., Erie, Pa.
Executive Committeeman (one year)
James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

Note: Article VII, Sec. 3, TAPPI Constitution: "Other nominations, if signed by at least 25 voting members, may be submitted to the Secretary of the Association, in writing, on or before November 20, and if each nomination so made is accepted in writing by the nominee, the name shall be placed on the official ballot."

Annual Meeting Papers

All individuals and committees planning to present papers at the annual meeting of the Association (Feb. 19–22, 1951) should submit manuscripts, in quadruplicate, to the Secretary of the Association by Dec. 1, 1950. Anyone still wishing to present a paper should notify the Secretary immediately.

Fibrous Agricultural Residues Conference

The Conference of the TAPPI Fibrous Agricultural Residues Committee was held at the Northern Research Research Laboratory, Peoria, Ill., on Nov. 13–14, 1950.

The conference was opened by S. I. Aronovsky, Chairman of the Fibrous Agricultural Residues Committee who introduced the individuals present. R. T. Milner, Director of the Northern Regional Research Laboratory extended those present a welcome to visit the Laboratory.

A more complete report will be given later. Following are the papers that were presented:

1. "Protecting Large Stacks of Baled Straw with Sisalkraft," by Ralph J. Anderson, The Sisalkraft Company, Chicago, Ill.
2. "Why Cut Straw?" by M. L. Rankin, Taylor, Stiles & Company, Riegelsville, N. J.
3. "Strawboard Mill Layout at H and D, Trenton, Ontario," by W. H. Palm, Hinde & Dauch Paper Company of Canada, Ltd., Toronto, Ont., Canada.
4. "Handling Practices for Liquid Caustic Soda," by R. A. Springer, Diamond Alkali Company, Cleveland, Ohio.
5. "Review of Theory in Application of the Jonsson Screen," by Sven Fahlgren, Bird Machine Company, South Walpole, Mass.
6. "Disk Mill Refining of Strawboard Pulps," by L. E. Eberhart and C. K. Textor, Bauer Brothers Company, Springfield, Ohio.
7. "Results with Turbo Pulp Refining," by L. F. Herman, Gruendler Crusher and Pulverizer Company, St. Louis, Mo.
8. "Straw Procurement," Round table discussion.
9. "A New Method of Cleaning Straw Pulp," by C. G. Krancher, Ball Brothers Company, Noblesville, Ind.

Following the presentation of papers a plant tour was made of the Pabst Brewing Co., at Peoria Heights, Ill. This was followed by a dinner in Blue Ribbon Hall, after which L. W. Hesse, Director of Community Relations, Keystone Steel & Wire Co., at Bartonville, Ill., talked on "What is Today's Steel Situation."

On Tuesday November 14 reports were presented by the subcommittees of the Fibrous Agricultural Residues Committee. One of these dealt with the experiments being carried out on straw preservation. A demonstration of the laboratory corrugator was presented, together with a report on results. This was followed by a tour of the Laboratory and of the plant of the Keystone Steel & Wire Co., at Bartonville.

Water Vapor Permeability

The TAPPI Packaging Materials Testing Committee is interested in having the names and addresses of all individuals and laboratories that use TAPPI Standards T 448 (Water Vapor of Paper and Paperboard), T 464 (Water Vapor Permeability of Sheet Materials at High Temperature and Humidity), and T 465 (Creasing of Paper for Water Vapor Permeability Tests). These methods are being revised. Individuals using these methods are requested to write to L. E. Simerl, Marathon Corp., Menasha, Wis.

TAPPI-M.I.T. Men Attention

Members of the alumni of the Massachusetts Institute of Technology who will attend the TAPPI annual meeting will hold a luncheon on Wednesday, Feb. 21, 1951. D. F. Lowry of Penick & Ford, Ltd., 420 Lexington Ave., New York 17, N. Y., is Secretary of the M.I.T. Alumni Group and would like to hear from any M.I.T. men who have not been receiving notices for previous luncheons so that their names can be added to the mailing list.

Bound Volume Tappi 33

Several readers requested that the Technical Section of *Tappi* 32 (1949) be bound for them. Arrangements can be made to supply bound volumes of the present Volume 33 (1950) for those who wish to have this done for them. The price of a bound volume will be five dollars. Please advise R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 East 42nd Street, New York 17, N. Y., if you desire to obtain a bound copy of the current volume of *Tappi* (Technical Section only).

Fifth Engineering Conference

About 350 engineering representatives of paper companies and suppliers attended the Fifth Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry which was held at the Netherland Plaza Hotel in Cincinnati, Ohio, Oct. 2–5, 1950.

The meeting was opened by George H. Pringle of the Mead Corp., Chillicothe, Ohio, General Chairman of the Engineering Division of TAPPI and by A. E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt., President of TAPPI.

Opening Remarks—A. E. Bachmann, President of TAPPI

We meet here once again this morning to begin our 5th Engineering Conference. It seems but a very short while ago that the activities of the Engineering Division were focussed into an annual Engineering Conference largely through the inspiration and efforts of our Past-President, G. W. E. Nicholson, and your former general chairman and present Secretary, J. W. Hemphill, aided to a very large degree by your present General Chairman, George Pringle.

Your response to this type of meeting in the form of the enlistment of capable committee leadership and the membership's production of large quantities of truly significant papers, has really been remarkable within so short a time. As the result of the high caliber of your papers and the regular attendance of a high proportion of the industry's top flight engineering talent, you have established this meeting as one of the real highlights of TAPPI activity. The ever-increasing attendance of some of the industry's top production men gives further indications of the interest of the industry's management in the affairs of this Division. TAPPI is truly proud of the accomplishments of this Division in the past and sincerely hopes that you will all keep up the keen interest which has resulted in its present high standards.

In delivering encomiums to the Engineering Division we would indeed be remiss if we failed to note the important part played in its success by an important group of our members, the engineers of our affiliated industries. You will note the use of the description Engineers rather than Salesmen. These engineers have given us much of their specialized knowledge. As a matter of fact, they are indeed in many cases the real specialists of our engineering group to whom we all look for education on specific details of many phases of the engineering field.

Too often I fear we are apt to take the daily work of our engineers too much for granted. Great amounts of ingenuity are involved in drawing upon this vast field of specialized knowledge required for plant layouts, machine design and that all inclusive field, the ability to fix anything, known as maintenance. Our engineers also, almost from the beginning of their careers have been exposed by the nature of their daily work, probably more than any other group of technical men, to assuming responsibilities. Measurements must be exact, speeds must be synchronized and elements must fit together. Our engineers also in order to be able to install them properly must, of necessity, have a considerable responsibility in choosing many types of capital equipment.

To properly fulfill their requirements of jobs in terms of initiative and responsibility, our engineers require a vast knowledge covering broadly and even in specific detail many phases of the sciences of Mechanical, Civil and Electrical Engineering, Heat and Power, Electronics, Machine Design, as well as the whole field of Pulp and Paper Process Engineering and Maintenance.

It is the function of TAPPI and particularly these Engineering Meetings to make available to all through papers and personal contact on common problems a greater comprehension of these vast fields of knowledge. If each one makes an effort to present and share their individual specialized contributions to this educational pool, we will all be enabled to get the broad perspective that we need for a well sounded broad background of usable information to enable us to cope with the wide variety of engineering and capital equipment problems encountered in our daily work.

One of the important ways that we can all contribute to such a pool of knowledge lies in the production to a greater degree of our engineering data sheets to the ultimate end that some time in the future they can be combined into an engineering handbook specifically adapted to the needs of our industry. We hope that you will all make every effort to contribute your mite to this long-continuing project by writing down and sending into your committee chairmen the products of your engineering research, which is of common application.

A. E. Bachmann, President of TAPPI

G. H. Pringle, General Chairman Engineering Division

We hope indeed that you will all enjoy and profit from the program which has been arranged for you by your committee chairmen. I now take great pleasure in turning over the meeting to your General Chairman, George Pringle.

After the opening remarks, the session was turned over to the Mill Design and Economic Aspects Committee. This committee has been headed by Alvin H. Johnson who expected to be present but who unexpectedly passed away two days prior to the meeting. A period of silence in respect to him and to Merton S. Fogerty formerly Chairman of the Mill Maintenance Committee and G. H. Young, Secretary of the Drying and Ventilating Committee, both of whom passed away since the last conference, was observed. They were outstanding in their efforts to assist the work of the Engineering Division.

Mill Design and Economic Aspects

H. W. Gehm of the National Council for Stream Improvement, New York, N. Y., spoke first on the subject "Engineering Planning for Handling Mill Waste Waters." His discussion related to the effect of modern kraft mill design on the quantity and quality of effluents discharged from such units. The increased recovery efficiencies brought about by the improved pulp washing, liquor evaporating, and other equipment have reduced both the quantity and quality of the liquid wastes discharged to a significant degree. Well integrated mill design is capable of keeping sewer losses to a level where they approach the point of diminishing returns. Both good sewering practice, sampling, and control instrumentation are capable of assisting operators in maintaining consistent high effluent quality as are several specific design features which serve to prevent periodic liquor and fiber losses. Much can and has been accomplished in minimizing stream pollution by the above means and the most satisfactory time to apply them is in the original installation.

It had been expected that Roland A. Packard of the Holyoke Machine Co., Holyoke, Mass., would continue with the subject of his report given at the Fourth Engineering Conference which was held in Boston. In this paper Mr. Packard went back a hundred years into the very crude methods employed to operate a paper machine. The maintenance of a constant speed, once that speed was decided upon, was of great concern to early papermakers, and various means were developed to accomplish that end. The Marshall train, and the variable speed, single motor or stream turbine on a line-shaft drive with either the V or flat belts brought the treatise down to the sectional motor drive. Clutches and couplings were dealt with separately. Curves of machine speeds for making different kinds of paper and board were given. Costs per horsepower of different kinds of drives were developed

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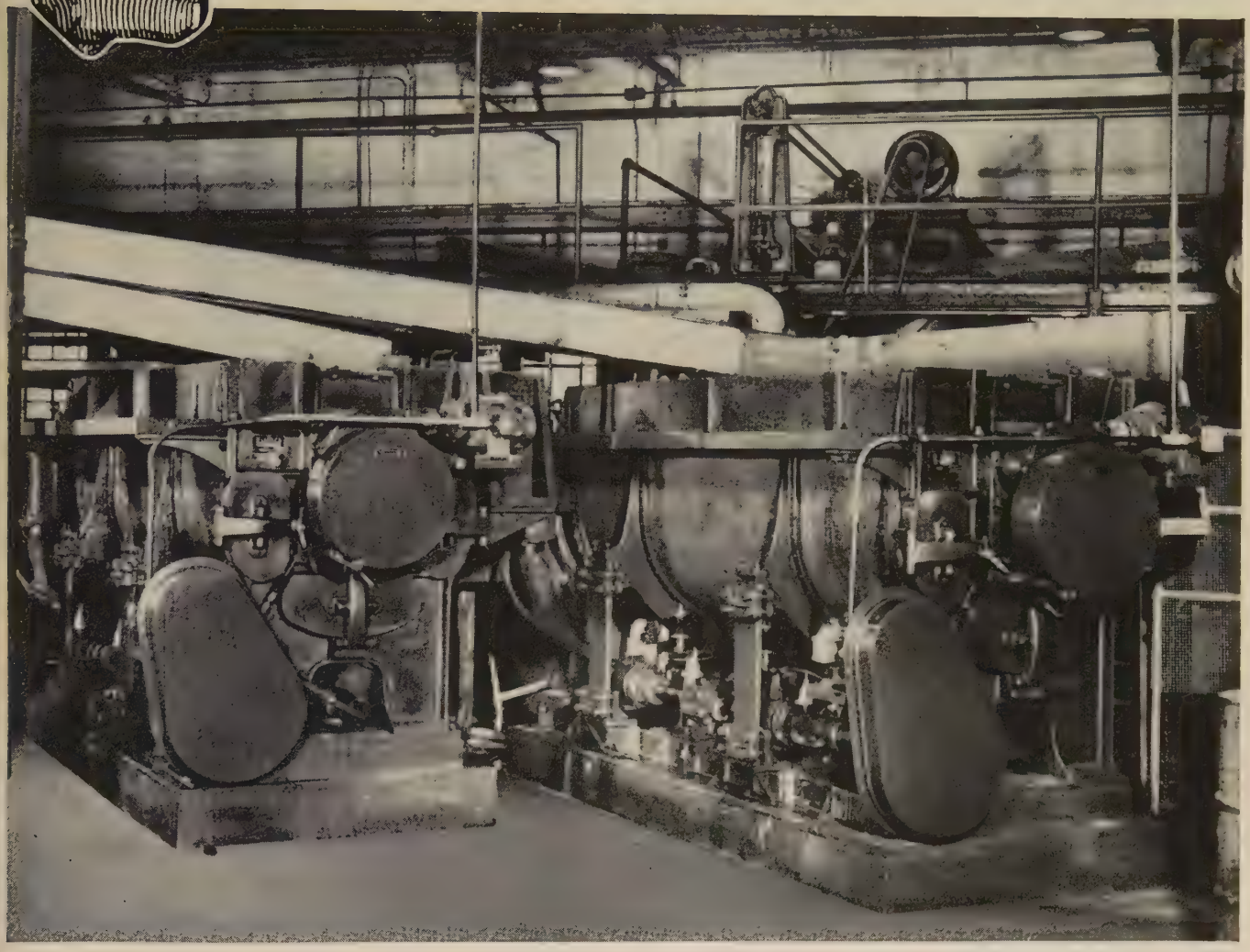

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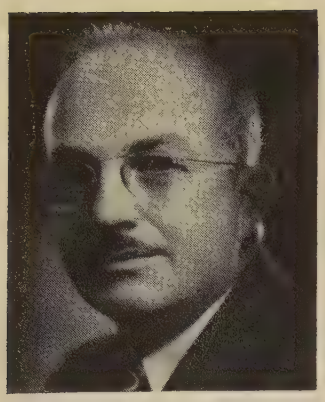

K. J. Mackenzie, Chairman of Hydraulics Committee

John D. Lyall, Acting Chairman of Engineering Research and Machine Design Committee

into graphs. This paper was published in the February, 1950 issue of *Tappi*.

However, because of the pressure of his other activities, Mr. Packard was not able to give a final report on the second phase and so gave an outline of his intended project.

Part II will continue with the cost angle giving data and curves on installation expense which combined with the purchase prices of drives affords information for complete first cost of different kinds of equipment ready to operate a paper machine. Characteristic over-all mechanical and electrical efficiency curves will be given for different kinds of drives including hydraulic, packaged V belt, V belt short center, hypoid, spiral, and sectional electric drives. Data will be given on over-all production efficiency in the operation of the paper machine insofar as the drives are concerned. In deciding on a certain type of drive the picture is not complete without knowledge of what it will cost to maintain the equipment. Today, it is essential to keep this cost as low as possible commensurate with high-operating efficiency. A summary of both parts of the paper will complete the analysis of the selection of the paper machine drive. Assistance in assembling these data was requested by Mr. Packard in closing.

Hydraulics

The meeting was then turned over to K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., Chairman of the Hydraulics Committee. Mr. Mackenzie first reviewed two articles which were translated by Sven A. Quist from Swedish. They were "Pumping of Paper Mixtures" by K. Klarfelt and "Investigation of Friction Losses Encountered in Connection with Pulp Flow in Stripe Pipe" by Britt-Maja Nilson.

These reviews were followed by a discussion of some of the data of Brecht and Heller by Geoffrey Broughton of the Lowell Textile Institute, Lowell, Mass. The paper was published in the September issue of *Tappi* and Mr. Broughton discussed the date for the flow of sulphite pulp through two smooth copper pipes of different diameters. It was shown that the initial portion of the consistency curves drawn from their results can be expressed by the equation:

$$\frac{PR}{2L} = \eta \left(\frac{4V}{R}\right)^{0.39}$$

where

P = pressure drop poundals per square foot per 100 feet
R = radius of the pipe
L = length of the pipe (100 feet)
η = apparent viscosity
V = velocity ft. per min.

The exponent 0.39 is independent of pulp concentration while η is given by the expression

$$\eta = 0.87C^2$$

where C is the pulp concentration in per cent.

It is believed that the final portion of the consistency curve is turbulent in nature, there being a transitional zone, the nature of which is affected by such factors as pipe roughness, stock character, degree of beating, etc. The maximum shearing force at the end of the initial portion of the curve is identical for different pipe diameters and can be predicted by the empirical equation:

$$\frac{PR}{2L}_{\text{max.}} = 2.30C^{2.46}$$

Some experiments were suggested as essential for further clarification of the problem.

Practically all the Engineering Division Committees had luncheons at which they discussed their future plans. This procedure has become a feature of the engineering conferences for it permits a more formal meeting of the committee without affecting the general program.

Engineering Research and Machine Design

After lunch John D. Lyall, Armstrong Cork Co., Lancaster, Pa., Chairman of the session introduced F. Richardz of the Westinghouse Electric Corp., Pittsburgh, Pa., who spoke on "The Application of Enclosed Gearing in the Pulp and Paper Industry." In processing pulp and paper, it is important that the mechanical equipment produces the desirable speed at the required horsepower. The most commonly used mediums for reducing the prime mover speed to a usable speed for the application are: belts, open gears, chains, enclosed gear reducers, and gear motors.

Enclosed gear drives provide many distinct advantages such as: high efficiency, compact size, safety, low maintenance cost, reliable operation, uniform transmittal of rotation and excellent for transmitting synchronized (slip-free) motion.

Since the concept of the American Gear Manufacturers' Association (A.G.M.A.), it has been their aim to correlate application data used by the various gear manufacturers into a standardized industry practice. The A.G.M.A. has also been instrumental in standardizing rating practices as well as lubrication instructions, output speeds, gear ratios, etc. The gear manufacturers, together with the tool builders, have perfected gear cutting and gear finishing equipment and processes to provide gearing of highest quality standards, low in sound level, and long useful gear life. In the last quarter century, the gearing industry has made more progress than in all its previous history and new developments are constantly in process.

Following this paper J. A. Smith discussed "Air Removal from Stock Ahead of the Headbox." Air in stock has long been a problem to the papermaker. Air affects formation, flocculation, slime, stock hang-up, pin holes, and sheet porosity, as well as breaks and down time. Antifoaming agents and showers may inhibit the foam or break air bubbles but do not remove air which is attached to individual fibers.

The Deculator which removes all measurable air from paper stock at normal headbox consistencies was described. This process utilizes high vacuum in conjunction with the acceleration of the finely divided stock particles, impinging them against a hard surface.

When applied to a production newsprint machine, foam and air bubbles disappeared from the surface of the stock in the headbox. The vacuum at the couch roll increased 3 inches from 19 to 22 inches, and the dryness leaving the couch increased by 1%. The smoothness of the finished sheet on both felt and wire sides increased 20% without changing the calender roll weights or moisture content. The porosity decreased 25% as measured on the Gurley densometer. The tonnage increased about $2^1/_2$% due to the reduction in down time from breaks.

The Deculator process uses new techniques in stock flow, control and vacuum producing equipment, and stock pump design. The stock flow is controlled automatically with air

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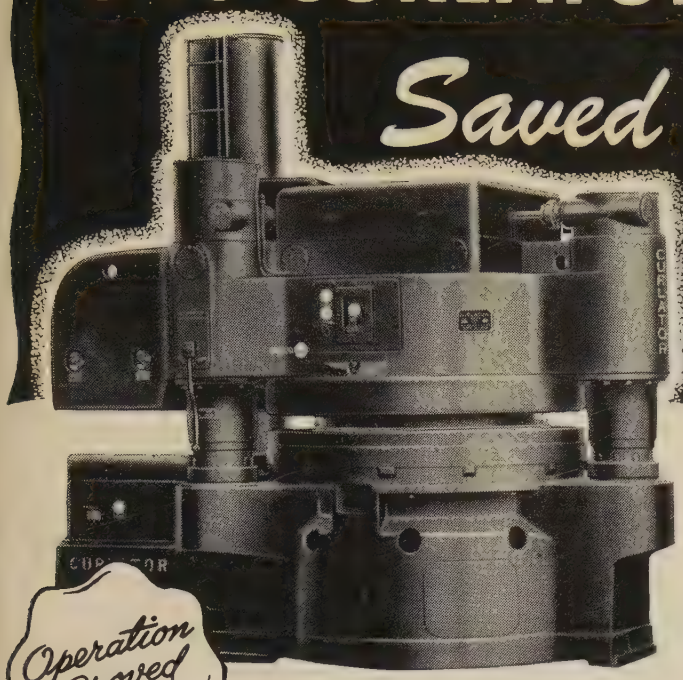

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A. P. Schnyder, Chairman of Materials Handling Committee

H. F. Parker, Chairman of Mill Maintenance and Materials Committee

operated valves responding in synchronism to regulate the flow corresponding to that of the manual valve settings by the papermaker. The vacuum producing equipment requires no operating control adjustments, as this equipment functions at fixed valve settings and pump speeds.

Other types of stock such as kraft and sulphite have been deaerated successfully in the laboratory, and several more installations will be made in the near future. This process offers a means whereby higher speeds beyond present limits may be achieved without lowering sheet quality.

Considerable discussion developed from this last paper and it was necessary, because of time limitations, to proceed with the next session on the program.

Materials Handling

The Chairman of this session was A. P. Schnyder of the Ebasco Services, Inc., of New York. Because of the illness of H. F. R. Weber his paper "Handling of Finished Pulp and Paper Products from the Machine to the Shipping Dock" was presented by another representative of the Link Belt Co.

Production has been defined as materials in motion. There are two motions involved—processing motion and handling motion. Processing motion adds value to the product, while handling motion simply adds cost. The greater part of indirect labor in most industries is engaged in moving and handling of materials. And, in many industries, a surprising amount of what is usually considered as direct labor, is engaged in a similar purpose. Few manufacturers realize or appreciate the tremendous amount of time and money used daily merely to move material, or to use the generally accepted term "materials handling." It has been suggested that a fair average ratio for all manufacturing industry would be that 50 tons of material are handled to produce 1 ton of finished product. An exact figure for the paper industry is not available, but it would be close to the average.

Advantages of modern methods of handling materials are many. Some are noted as follows: reduced indirect labor costs, increased capacity of existing buildings, increased turnover, reduction of fatigue, conservation of skilled production labor, reduced cost of transportation, greater industrial safety, and improved attitude of workers operating mechanized equipment instead of doing hard manual labor.

These advantages apply to the materials handling problems involved in every step of paper production—from forest to shipping room. The necessity for handling finished pulp and paper products warrants especially careful study. Since they have been completely processed, additional handling motions do not increase the value of those products but only increase their cost. Where such movements are necessary, properly designed and applied materials handling equipment can reduce those costs.

Many machines and devices are available for solving the problems of handling finished products. There are overhead cranes, monorails, trucks, tiering and manipulating units, gravity roller conveyors, powered conveyors, elevators, lowerers, and many others. A few were discussed, these being roll elevators and lowerers, pallet-type conveyors, both flush and elevated—these for handling rolls of finished paper, together with apron conveyors for handling bales of pulp, and trolley conveyors for handling trucks in a warehouse. The examples noted cover but a few of the types available for handling finished pulp and paper products. Each installation has been developed to solve a specific problem having as the final objective in each case the reduction of handling costs.

The possibilities of cost reductions by use of material handling equipment are often obscured by familiarity with, and unchallenged acceptance of customary methods or operations. For that reason, most mills could profit from a thorough study of their processes and intraplant transportation of materials in order to determine where potential savings are possible.

The last item on Monday's program "Outstanding Practices in Materials Handling in the Pulp and Paper Industry on the West Coast" was an excellent paper given by F. D. Helversen of the Crown-Zellerbach Corp., Portland, Ore. The presentation consisted of 19 actual cases, illustrated by 68 slides, of outstanding material handling practices on the West Coast. The paper was the cooperate effort of five West Coast companies who endeavored to show the most modern and useful material handling methods employed in their operations.

Only actual practices were shown as it was felt that the illustrations of actual practices stimulate reuse to a greater extent than theoretical considerations, because after all, the ingenious reuse of already developed methods is the greatest part of progress.

The actual practices illustrated were the use of a movable spar in cable logging operations, a logging truck preloading device, a movable boom and skidder in logging operations, a seed cone stripper, seed attachment to helicopter, the use of air tongs in loading logs on trucks, log handling at a wood mill, wood mill handling of logs, chip handling from railroad cars, chip storage and handling at mill, pulp handling from machine to a railroad car, handling of paper rolls from ship to dock or vice versa, handling of large diameter rolls, conveyor application on stitcher machines, material handling system in a converting plant, material handling system in a paper wholesale warehouse, and experiments with glue locked unit loads.

Each of the 19 cases shown in the slides, along with a brief description, represented the practices at 19 different, widely dispersed locations, which could hardly be seen by one person in less than 2 weeks' traveling.

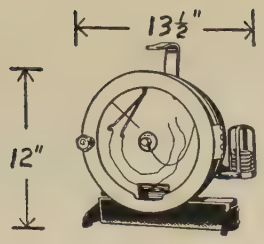
Mr. Helversen remarked that many more outstanding practices exist than were presented but that it would take considerably more time to assemble examples for presentation.

Mill Maintenance

The first paper on Tuesday's program was "Teflon in Process Equipment" by D. B. Hansen, E. I. du Pont de Nemours & Co., Wilmington, Del., who was introduced by H. F. Parker, of the New York and Pennsylvania Co., Lock Haven, Pa., Chairman of the session.

"Teflon" tetrafluoroethylene resin is finding an important place among the materials used in equipment for the process industries. It has been a unique combination of properties—practically universal resistance to chemical attack, heat-resistance suitable for continuous service at temperatures up to 500°F., electrical properties equal to those of the best insulating materials known, and outstanding nonadhesive properties, so that even very tacky materials show little tendency to stick to its surface.

Since its discovery 10 years ago, manufacture of Teflon has come through the pilot-plant stage and has reached commercial-scale production in April, 1950. Since the granular polymer is not soluble in anything and does not melt and flow



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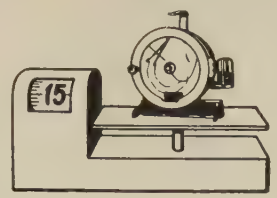

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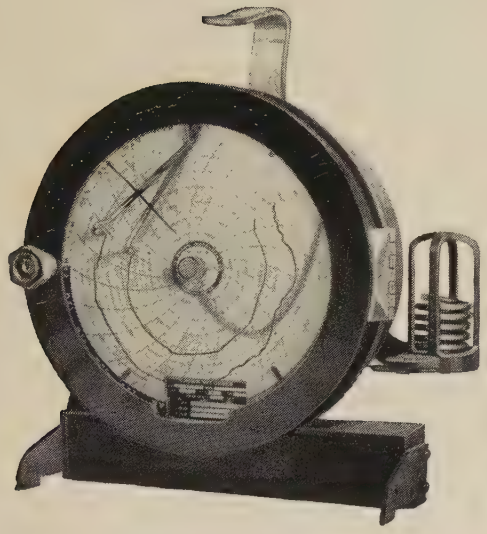

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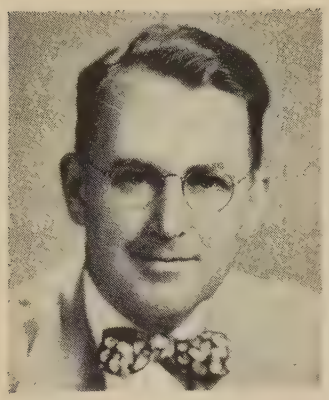

Henry J. Perry, Chairman of TAPPI Data Sheet Committee

M. L. Barker, Chairman of Drying and Ventilating Committee

as do conventional thermoplastics, it has been necessary to fabricate articles by special techniques similar to those used in molding powdered metals. By such procedure the granular powders is made into sheets, rods, tubes, and other relatively simple shapes. Articles of complex contour are usually machined from such standard shapes.

Recently Teflon has been offered in the form of a suspensoid, a stable dispersion of very small particles in water. The suspensoid has been used in making finishes for coating metals, glass, and ceramics, in formulations for wire-enamels, and in impregnation of fabrics of asbestos and of glass.

Application for Teflon fall into four general classes—chemical, nonadhesive, electrical, and wire-insulation. Numerous examples of applications in these four fields are available, and such case histories should be helpful in suggesting similar uses in the pulp and paper industry. The chemical and nonadhesive properties are of particular interest because they are being utilized in process equipment to reduce maintenance, increase productive capacity, reduce wear, simplify design, and avoid contamination of the product being handled.

Henry W. Downs, Jr., of the Union Screen Plate Co. of Canada, Ltd., gave the next paper "Slotted Screen Plates for Pulp and Paper Mills."

Slotted screen plate may be divided into two broad categories; namely (1) flat plates for flat diaphragm screens, and (2) curved plates for rotary screens.

Flat plates, in general use today are manufactured from Inconel, stainless steel, chromium-plated bronze for general use; nickel-plated bronze for unbleached sulphate; and unplated, cast, resisting bronze, which may be classified in order of quality as listed above; Inconel being the best and unplated bronze the poorest.

The style of plates generally used for different applications are as follows:

Board mills	Style A	4 or 5 slots per inch
Sulphate mills	Style C	5 slots per inch
	Style E	6 slots per inch
Sulphite mills	Style C	6 or 8 slots per inch
	Style E	8 slots per inch.

Tailing screens for Bird paper machine screens, Style B—9 rows of slots, 4 slots per inch—screens equipped with scraper—Style B.

Typical examples of gages or slots used in Canada are as follows:

Board Mills—0.020, 0.024, or 0.026 inch.
Sulphate mills—0.010, 0.012, and 0.014 inch with main screening carried out on 0.012-inch cut plates.
Sulphite mills—0.006 or 0.007 inch, 0.008 and 0.009 inch, with main screening carried out on 0.008-inch cut plates.

The screening capacity of plates varies widely from mill to mill according to kind of pulp being screened kind of screen being used, condition of the screen, type of plate, and gage of slot from 600 pounds per plate to over 2000 pounds.

There are three general methods of fastening flat screen plates used in Canada: (1) square edge plates drilled and countersunk for screws, (2) beveled and grooved for Union fastener, and (3) beveled 28° for Witham and similar type fasteners.

The materials used for screen plates for rotary paper machine screens in order of quality are as follows: (1) Inconel, (2) stainless steel, (3) chrome-plated rolled phosphor bronze, (4) chrome-plated hard-rolled copper, (5) unplated rolled phosphor bronze, (6) unplated hard-rolled copper, and (7) rolled yellow brass.

Data Sheets

The next item on the morning program was a review of the activities of the Data Sheet Committee by Henry J. Perry of the Paper Trade Journal, its chairman. Mr. Perry again emphasized the need for the cooperation of all the members of TAPPI. Anyone who has material which he thinks would make a good Data Sheet is earnestly requested to forward it to the committee.

Drying and Ventilating

M. L. Barker of the Beckett Paper Co., Hamilton, Ohio was the chairman of this session. He introduced L. C. Crowder of the Macon Kraft Co., Macon, Ga. who gave his paper "Drying 800-tons Kraft Paper Daily on One Machine."

Record tonnages of linerboard are being set on the most modern paper mill equipment available, consisting of a machine with 102 paper driers and the longest drier hood installation in the world. Air for vapor removal is handled in quantities in excess of 1,000,000 c.f.m.

Water removal on the machine is shown to be very heavy at the wet end, with the preponderance of capital investment being in the drier section to remove a quantity of water which is small compared to the total quantity coming to the wire.

The operating conditions prevailing on the day when a record of 838.99 tons was produced, allow the computation of drying rates, both as pounds of paper per square foot of drying area, as well as pounds evaporation per square foot. A comparison of drying rates on other grades, against the 1939 production drying rates and evaporation drying rates established by Montgomery seem to bear out the slope of the evaporation drying rate curve, and indicate that the production drying rate curve may be on a slightly less slope than originally determined.

Strict attention to maintenance of suction rolls, drier syphons, condensate, and noncondensable removal equipment on present machines will go far toward improvement of drying rates since the trend seems to be higher machine speeds with the resultant necessity of higher drying rates.

The Ross pulp drier was described next by J. F. Gschwind, J. O. Ross Engineering Corp., New York, N. Y.

Until recently pulp was dried on regular cylindrical steam heated driers, or sometimes in driers using radiation from steam coils. Some of the objections to be overcome are too high steam usage, damage to strength of pulp, as well as lowering of brightness.

Steam leakage is a common objection in the use of steam coils, besides the fact that they collect dirt and lint, and vacuum driers are too costly.

In this new system of drying these design objects were kept in mind: (1) accessibility of all parts, (2) thermal efficiency, (3) sound design to reduce maintenance, and (4) product improvement.

The main points in the construction of the drier are as follows: the wet sheet of pulp is brought in on traveling crossbars which run back and forth horizontally and downward until the pulp is dry, when it emerges at the lower far end. The

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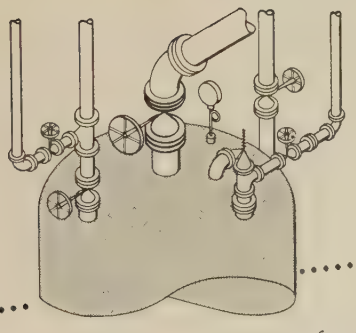

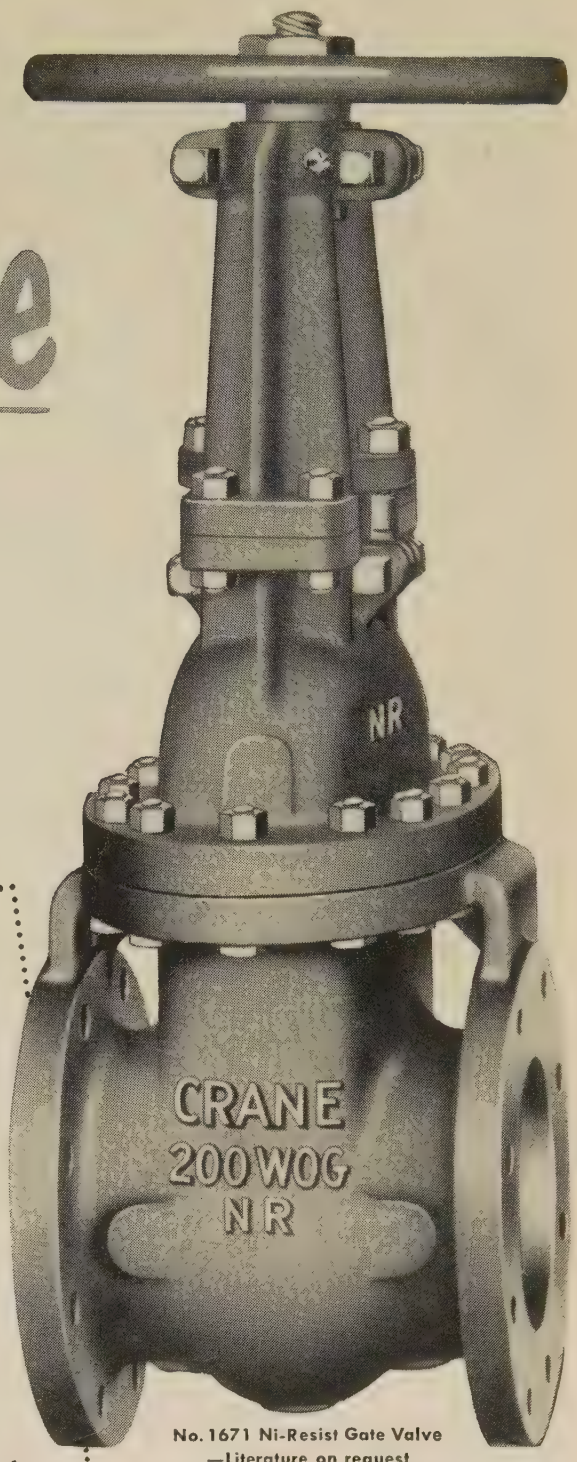

No. 1671 Ni-Resist Gate Valve —Literature on request through your Crane Branch or Crane Wholesaler.

PROBLEM: To find a better replacement for valves that needed repairs every 2 to 3 weeks and failed completely in 3 to 4 months.

WORKING CONDITIONS: Valve exposed constantly to hydrochloric acid vapors at 50 psi, at approximately 280° F., while controlling raw material inlet line to starch converter.

SOLUTION: Crane No. 1671 Ni-Resist Cast Iron Gate Valve with Crane 18-8 Mo Alloy trim.

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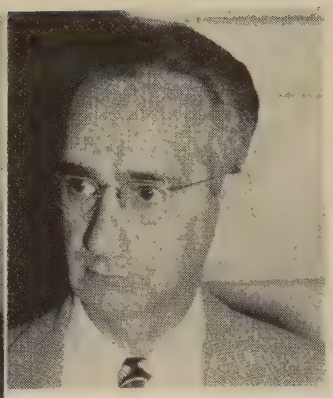
C. J. Sibler, Chairman of Steam and Power Committee



A. S. Goodrich, Chairman of Electrical Engineering Committee

drying is done exclusively by hot air, uniformly distributed by headers. Both sides of the pulp are dried by hot air which, in turn, is heated by copper tubes with fins using steam under pressure. The air is handled by large fans. There are catwalks inside the drier to facilitate inspection and cleaning, which has been relatively easy on the machines built so far. Usually a variable speed drive is employed. If it is found advisable, step-wise temperature control can be employed.

Round Table Discussions

Tuesday afternoon was devoted to Round Table Discussions by several of the committees. The Materials Handling, Data Sheets, and Drying and Ventilating Committees had informal discussions of their various interests.

G. F. Hrubecky of the Marathon Corp., Menasha, Wis., acted as moderator at the Mill Maintenance Round Table discussion on mill roofs. After mentioning the various types of roof covering most likely to be encountered—wood shingles, tiles, slates, asbestos or composition shingles, single-ply roll roofing, built up with and without gravel, metal—Mr. Hrubecky listed the types of roof decks—wood, metal, concrete (which includes haydite or any other lightweight concrete aggregate), gypsum, kalo, and foam glass. He then listed such elements that make up a roof such as the pitch, ridges, valleys, parapets, drains and gutters, roof projections such as skylights and ventilators, fastenings to roofs, and expansion joints. With this outline he opened the discussion of roofs and their maintenance.

George E. Clink, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y. opened the Engineering Research and Machine Design Round Table.

Considerable thought is being given to standardization of various parts of machines. It seems equally desirable to standardize the various factors which determine the design of these parts. Some of these factors are the tensions carried in the fourdrinier wire, board machine wet felts, and regular press felts, as well as the nip pressures between various rolls on machines.

Wire Tension—The fourdrinier wire, mechanically, is a belt which drives the table rolls, wire rolls, and breast roll and, as such, has a tight side or load carrying side and a slack side tension. The greatest load on the wire is caused by the suction boxes, and as this is next to the couch the loadings of the breast roll and wire rolls are primarily dependent on slack side tension. Various values of this tension may have been assumed from 5 to 20 pounds per inch of width. As wire life and the design of various elements of the machine are dependent on this tension it would seem desirable to determine more accurately this tension.

Felt Tension—Felt tension like wire tension determines the design of a good many elements of a paper machine. Fifteen to twenty pounds per inch of width have been assumed in many cases where as some investigators report tensions varying from 8 to 40 pounds per inch. Felt life and water removal are affected by this factor and hence it again seems desirable to obtain more accurate information.

Nip Pressures—The nip pressures between rolls on the paper machine influence felt life, crown of the rolls, the power required to drive the machine, the design of the rolls and its bearings. On the same type of press pressures from 100 to 400 pounds per inch are assumed.

It is understood that all of these factors vary from mill to mill and from machine to machine so that a fixed figure will not be obtainable. However, it is thought that by a survey of the industry that the range may be narrowed and that a pattern will be found for various papers and machines to the end that more accurate designs can be accomplished by the engineers and greater control accomplished by the mill.

Allied Industry Program

Tuesday evening was devoted to a get-together party in the Pavilion Caprice after which dinner was served in the Netherland Plaza Hotel's Hall of Mirrors.

H. H. Latimer of the Champion Paper & Fibre Co. acted as Toastmaster and introduced the Rev. Laurence H. Hall, Rector, All Saints Episcopal Church, Portsmouth, Ohio who gave a very humerous and entertaining talk.

Steam and Power

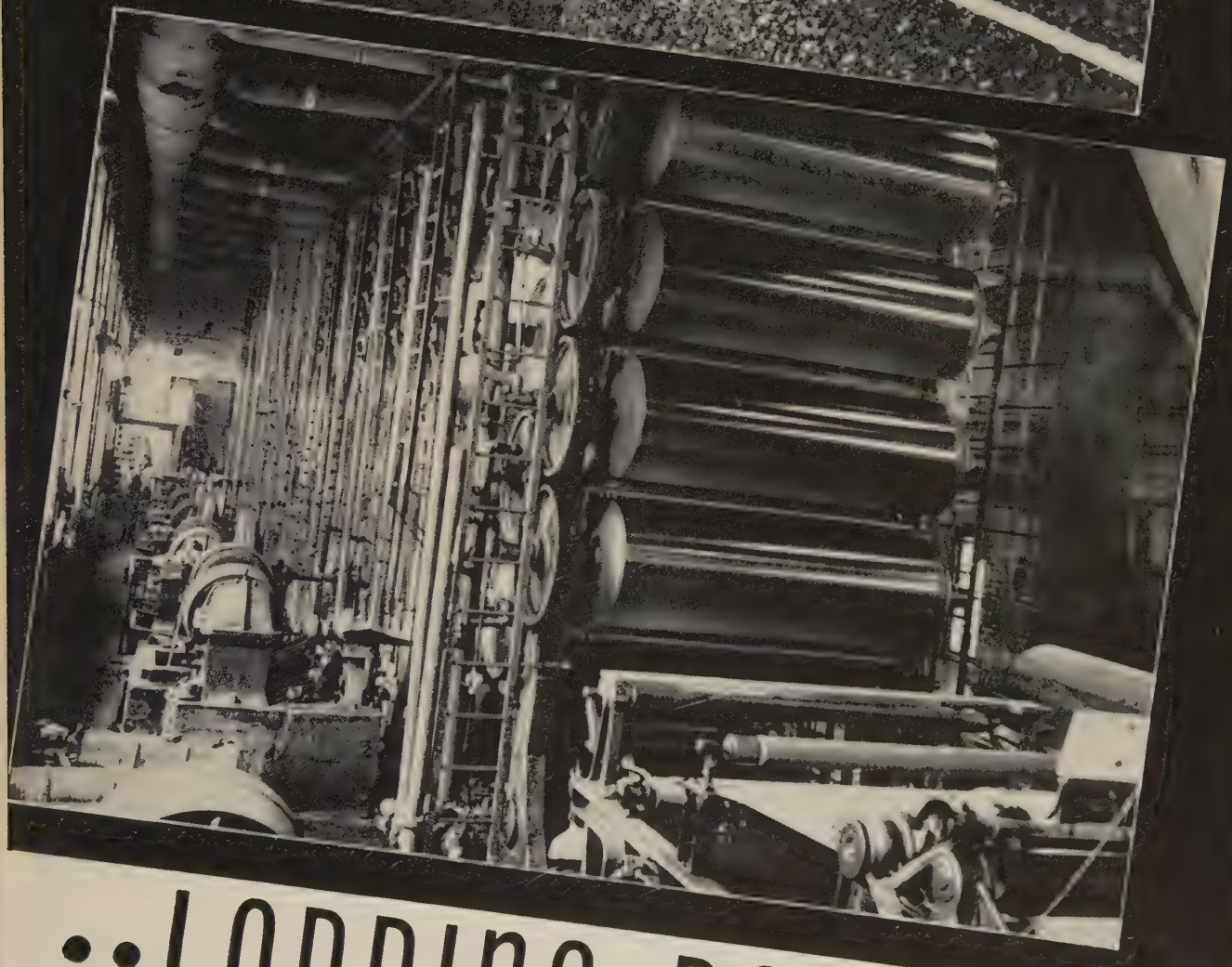
"Installation and Operation of the 1200-lb Steam Plant at the Union Bag & Paper Corp. Mill" was the first paper of Wednesday's sessions. It was given by H. R. Arnold, of Union Bag who was introduced by C. J. Sibler, West Virginia Pulp & Paper Co., Chairman of the Steam and Power Committee.

The application of high-pressure, high-temperature steam, while new to the paper mill industry, is by no means experimental. Equipment utilizing steam at pressures of 1200 pounds, 950° F.T.T. has proved in the public utility field to be equally as dependable operating under these conditions as low-pressure equipment. As paper mills continue to increase their production and conversion facilities, the trend is to demand higher pressures for the paper machine driers and more power for higher machine speeds and refining facilities. This invariably results in overloaded power generating equipment, frequency variations, a complete upset in the steam and power balance, and increased power and steam costs. It becomes the problem of every cost-conscious power engineer to study these conditions in the light of present-day operating problems, and to recommend to management the installation of equipment which will incorporate sound engineering, and realize a savings which will give the company a good return on its investment. This can only be accomplished when management is cognizant of the many variables affecting steam and power costs and its ultimate effect on the cost of finished product. The management of Union Bag & Paper Corp. very wisely saw fit to take advantage of the progress made in power engineering. As a result of this sound judgment on their part, power costs were reduced and production increased. It is not intended to create the impression that high-pressure steam and its related equipment is a cure-all for the many ills of paper mill power plants. Each mill presents a different problem and must be studied if the new equipment is to incorporate reserve for future growth and flexibility of operation.

In recent years, much emphasis has been placed on feed and boiler water conditioning, on internal treatment, on boiler water circulation, and on steam purification in connection with steam generating units for both industrial and utility steam-electric power plants. A new concept in boiler design, the dual circulation boiler was evolved for a specific application to enable steam to be generated at high pressure from feedwater of high make-up and unavoidably high solids concentration.

This was described by H. B. Wallace, Jr., of the Foster-

BEFORE and AFTER



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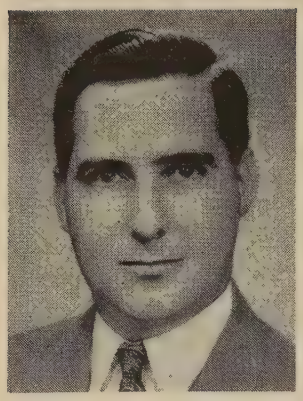
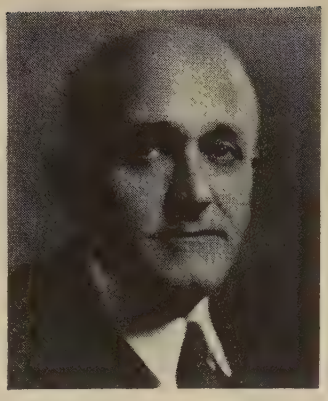


J. R. Lientz, Chairman of Chemical Engineering Committee



J. W. Hemphill, General Secretary, Engineering Division

Wheeler Corp., New York, N. Y. in his paper "Super Pure Steam for the Paper Mill with the Dual Circulation Boiler."

The dual circulation boiler employs multiple effect evaporation in two stages both within a single boiler setting. The first stage, or primary section, consisting of the furnace and furnace circulatory system, is blown down at a high rate to the second stage, or secondary section, consisting of the convection boiler and boiler circulatory system. In the primary section, the boiler water concentration is held to a low value because of the high rate of blowdown and hence this section may be subjected safely to the high rates of heat absorption expected in the furnace. Inasmuch as most of the steam delivered to the superheater is released from this section, the small amount of moisture carried over must be of the same purity maintained in the primary section and hence, the total steam contains materially less impurities than otherwise would be attainable.

The theory of the dual circulation boiler was given, and the features of the first operating units and subsequent units under construction were described. The steam drum internals which, in addition to accomplishing the separation of circuits, produce water-free steam for delivery to the superheater and steam-free water to the circulatory system.

Electrical Engineering

At the present time there is very limited information available in a combined form that can be used in selecting electric motors for use in a pulp and paper mill. The views of the subcommittee of the Electrical Committee in the selection of motors throughout the mill were given in the paper "The Selection of Electric Motors for Paper Mill Application." This was presented by R. F. Sorenson of the Union Bag & Paper Corp., who was assisted in the preparation of the report by W. V. Knight, Gaylord Container Corp., and R. W. Foster of the Champion Paper & Fibre Co.

General comments on motor application, spare motors, special motor application, and a tabulation listing committee recommendations were given. This report should be prefaced "Preliminary" as it is certain that much can be added to it by other mills and manufacturers represented here.

A pulp and paper mill presents some of the most difficult application problems of any industry. Motors must be applied in areas of temperature extremes, they are applied in very wet locations, and they are subjected to corrosive atmospheres and to direct contact with corrosive chemicals. Most mills operate on a 24-hour a day, 7-days a week basis with a few days a year devoted to a complete shutdown for maintenance of equipment. This means that electric motors, as well as other equipment, must operate continuously. Much of a paper mill is a straight-line production unit where if one process shuts down it will directly affect the processes preceding and following it. Thus it becomes very essential that motor failures be kept at a minimum, and that when a motor does fail it must be replaced with a spare motor as soon as possible.

Engineering Division Luncheon

The luncheon was held in the Hall of Mirrors with George H. Pringle as Toastmaster. The speaker for the occasion was the Hon. Albert D. Cash, Mayor of Cincinnati who spoke on "Some Impressions from Abroad."

Following the luncheon the Steam and Power, Electrical Engineering, and Chemical Engineering Committees had round-table discussions. These concluded the formal program of the conference.

Mill Visits

At 9 a.m. the next morning, Thursday, buses were at the hotel to transport those who wished to visit the plants in the area. One group visited the Allis-Chalmers Mfg. Co., Cin-

Group at the Engineering Division Luncheon which was held during the Fifth Engineering Conference sponsored by the Technical Association

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cinnati Rubber Co., and the Cincinnati Milling Machines Co. The others went to Hamilton to visit the Black Clawson Co. In the afternoon this second group was split, some going to the Armco Steel Co., and the rest to Shartle Bros. Machine Co., and the new Hutchins Power Station near Miamisburg, Ohio.

Although no group arrangements were made, quite a few individuals were welcomed at the paper mills in the Ohio area. A few of the paper companies were: Philip Carey Manufacturing Co., Lockland, Ohio; Champion Paper & Fibre Co., Hamilton, Ohio. Crystal Tissue Co., Middletown, Ohio; Fox Paper Co., Lockland, Ohio; Gardner-Richardson Co., Lockland and Middletown, Ohio; Howard Paper Mills, Aetna Division, Dayton, Ohio; Loraine Paper Co., West Carrollton, Ohio; Mead Corp., Chillicothe, Ohio; Miamisburg Paper Co., Miamisburg, Ohio; Oxford-Miami Paper Co., West Carrollton, Ohio; Sorg Paper Co., Middletown, Ohio; and Wrenn Paper Co., Middletown, Ohio. These manufacturing concerns make a wide variety of paper products such as roofing felt and building papers, printing papers of all kinds, paperboards, fine papers, tissue, and absorbent grades. Consequently, it was a good opportunity for the visitors to become acquainted with other plants in their respective fields.

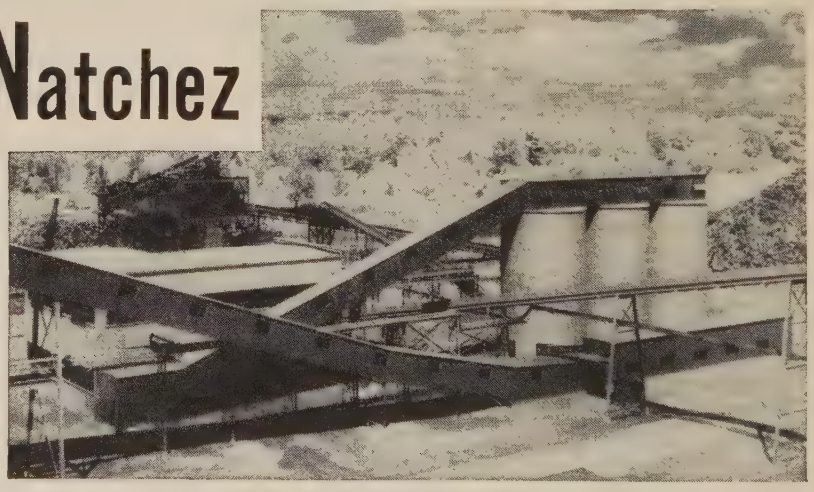
A large number of companies and individuals were responsible in making the Fifth Engineering Conference a success. To the managements of the manufacturing concerns and paper companies, their representatives who assisted with or attended the conference, and the officers and members of the Ohio Section of TAPPI, the Engineering Division is very much indebted.

Arrangement Committee

The following members and their companies constituted the Arrangement Committee of the conference sponsors:

Tony Agronin—Shartle Bros. Machine Co., Middletown, Ohio; E. E. Campbell—Hermann Mfg. Co., Lancaster, Ohio; L. B. Martin—The Jeffrey Mfg. Co., Columbus, Ohio; John P. Koester—The Orr Felt & Blanket Co., Piqua, Ohio; Wm. Knoll—The Midwest Fulton Machine Co., Dayton, Ohio; John H. Allison—Simonds Worden White Co., Dayton, Ohio; W. P. Strader—The Duriron Co. Inc., Dayton, Ohio; James Boyd—Manchester Machine Co., Middletown, Ohio; P. E. Howard—Mokry-Tesmer, Inc., Middletown, Ohio; G. H. Klouman—Armco Steel Corp., Middletown, Ohio; Raymond W. Brown—The Brown-Singer Co., Middletown, Ohio; E. E. Baker—Economy Pumps, Inc., Hamilton, Ohio; Theo. H. Pyle—The Lunkenheimer Co., Cincinnati 14, Ohio; Wilton H. Husing—The Wm. Powell Co., 2525 Spring Grove Ave., Cincinnati, Ohio; R. W. Davis—Allis-Chalmers Mfg. Co., Norwood Works, Norwood, Ohio; L. P. Darnell—The Cincinnati Rubber Mfg. Co., Cincinnati 12, Ohio; John B. Randolph—The Ohio Knife Co., Cincinnati 23, Ohio; Wm. W. Trunnel—The Regal Belting Co., 2125 Central Ave., Cincinnati 14, Ohio; W. H. Reuter—Littleford Bros, Inc., Cincinnati 2, Ohio; R. R. Newquist—Roots-Connersville Blower Corp., Connersville, Ind.; Joe Downs—A. D. Cook, Inc., Lawrenceburg, Ind.; Allen M. Crain—The Orville Simpson Co., 1230 Knowlton St., Cincinnati, Ohio; M. R. Sentman—The J. H. Day Co., Inc., Cincinnati, Ohio; D. E. Davidson—Link Belt Co., 307 N. Michigan Ave., Chicago, Ill.; C. W. Newkirk—The Wente Electric Co., 223 N. Fourth St., Hamilton, Ohio; A. W. Forbriger—The John Van Range Co., Cincinnati 2, Ohio; Mr. Churchman—Vulcan Copper & Supply Co., Cincinnati, Ohio; J. F. Freeman—J. F. Freeman & Son, Inc., Lawrenceburg, Ind.; Fred W. Kirby—National Electric Coil Co., Columbus 16, Ohio; and O. F. Hutchinson—Bulkley, Dunton Pulp Co., Inc., 295 Madison Ave., New York City.

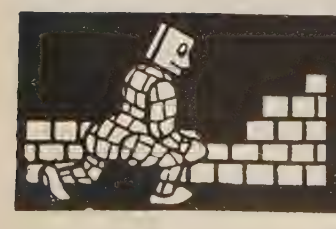
Stebbins at Natchez



WHEN the International Paper Company's new Southern Kraft Division mill began operation at Natchez, Mississippi, three large silos built of Stebbins reinforced Semtile construction were ready for storing the southern hardwood chips for processing into pulp.

Also the digesters had been lined with Stebbins thin carbon brick linings for complete corrosion resistance.

The low density bleach towers, washer vats, and many other tanks are Stebbins Semtile construction while all tile lined chests and towers have Stebbins Semplate linings to assure long life and clean, trouble-free operation.



SEMCO

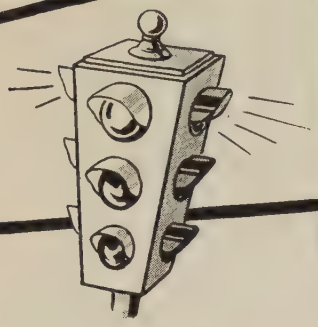
Stebbins Engineering and Manufacturing Company

WATERTOWN, NEW YORK

CANADIAN STEBBINS ENG. & MFG. CO., LTD. — CASTLE BLDG., MONTREAL, CANADA

STEBBINS ENGINEERING CORP. — TEXTILE TOWER, SEATTLE, WASH.

STOP STREAM POLLUTION... *Automatically*



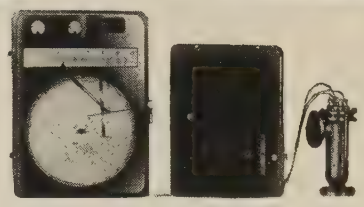
Bristol's pH Controller-Recorder puts plant waste neutralization on continuous, accurate, economical basis

If you are now neutralizing plant wastes manually —or are considering the installation of a neutralization system, a Bristol pH Controller-Recorder can standardize your results . . . prevent corrosion losses . . . utilize chemicals with maximum economy and safeguard stream and river purity.

A typical installation involves:

- a Bristol pH Controller-Recorder which continuously measures the pH of plant wastes and controls the flow of reagents to the mixing chamber to achieve a neutral value —
- and a Bristol Recording Flow-Meter which measures the volume of material to be treated, records the variations in the rate of flow and totalizes flow for record and cost-figuring purposes.

These Bristol Instruments are carried in stock for immediate delivery. Write for further information. THE BRISTOL COMPANY, 102 Bristol Road, Waterbury 91, Connecticut.



Bristol Continuous pH Controller-Recorder

TYPICAL UNIT CHEMICAL-PROCESS APPLICATIONS FOR BRISTOL pH INSTRUMENTS

Neutralization . . . to show when reagents have carried reaction to desired pH value.

Coagulation . . . to indicate when optimum pH value is attained.

Precipitation . . . to insure complete precipitation and proper physical properties of precipitate.

Fermentation . . . to insure that material remains within the critical pH range for maximum action.

Electro-deposition . . . proper pH determines efficiency of base metal plating.

Other Applications . . . crystallization . . . absorption . . . filtering . . . bleaching . . . settling. *Write for facts.*

Bristol makes a complete line of instruments for controlling sewage and industrial waste disposal processes, including recording thermometers, liquid level instruments, flowmeters, pH instruments, recording gauges, pyrometers, telemetering instruments, and automatic controllers.

BRISTOL

Engineers process control for better products and profits

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

PERSONAL MENTION

Items About New and Old Tappimen

New Tappi Members

Joseph Albert, Industrial Engineer, Kennebec Div., Hudson Pulp & Paper Corp., Augusta, Me., a 1950 graduate of Illinois Institute of Technology.

Amos J. Alter, Administrator, Alaska Water Pollution Control Board, Juneau, Alaska.

Carl C. Anderson, Professor, Technical University of Norway, Trondheim, Norway, a graduate of Oslo University, and the University of Heidelberg, Germany.

James R. Anderson, Sales Engineer, Clark & Vicario, Bronxville, N. Y., a 1938 graduate of Ohio Wesleyan University.

Oscar E. Anderson, Jr., Assistant Chemist, International Paper Co., Palmer, N. Y., a 1950 graduate of the University of Maine.

Edward S. Atkinson, Student, Tulane University, New Orleans, La.

Stephen J. Baisch, Design Engineer, Thilmany Pulp & Paper Co., Kaukauna, Wis., a 1942 graduate of the University of Wisconsin.

Richard K. Bamman, Engineer, Champion Paper & Fibre Co., Hamilton, Ohio, a 1940 graduate of the University of Maryland.

C. Nevin Betts, Paper Mill Chemist, Sonoco Products Co., Hartsville, S. C., a 1942 graduate of the University of South Carolina.

Tammo R. Beukema, Managing Director, N. V. Cartonfabriek Beukema & Co., Hoogezand, The Netherlands, a graduate of the University of Leiden with a D.Sc. degree.

Louis S. Biczak, Laboratory Supervisor, Hamersley Mfg. Co., Garfield, N. J. Attended Paterson College.

Carl L. Brickman, Chemist, Benj. C. Betner Co. of Va., Richmond, Va., a 1925 graduate of the Case Institute of Technology.

Russell A. Buck, Chemist, The Sorg Paper Co., Middletown, Ohio. Attended the University of Cincinnati.

Thomas O. Day, Jr., Manager, Milprint, Inc., Milwaukee, Wis., a 1941 graduate of the Georgia Institute of Technology.

David C. Edmiston, Jr., Student, University of Texas, Austin, Tex.

A. Raymond Esterly, Chemist, Catalin Corp. of America, Fords, N. J., a 1936 graduate of Pennsylvania State College.

John Fall, Chief, Acquisition Div., New York Public Library, New York, N. Y., a 1933 graduate of Columbia University.

Henry T. Fisher, Research Chemical Engineer, Ontario Paper Co., Thorold, Ont., Canada, a 1928 graduate of the University of London.

Clarence M. Flint, Research Director, American Newspaper Publishers Assn., New York, N. Y., a 1928 graduate of the University of Maine.

Pietro Ghisoni, Technical Manager, Cartiera Vita Mayer & Co., Milan, Italy, a 1936 graduate of the University of Milan with a Doctor of Ind. Chem. degree.

Jacob Gottlieb, Steam Power Engineer, Westinghouse Electric Corp., New York, N. Y., a 1921 graduate of Alabama Polytechnic Institute.

Lewis O. Gunderson, Assistant Vice-President, Dearborn Chemical Co., Chicago, Ill., a 1919 graduate of St. Olaf College; postgraduate work at the University of Wisconsin.

Jack L. Harvey, Technologist, Paper Section, Industrial Div., National Bureau of Standards, Washington, D. C., a 1947 graduate of the University of Cincinnati.

Malvern J. Hiler, Executive Vice-President, Commonwealth Engineering Co. of Ohio, Dayton, Ohio, a 1937 graduate of Michigan State Normal College.

Valentin Jaussaud, Manager, Papeteries de France, Brignoud, Isere, France.

Yun Jen, Graduate Student, N. Y. State College of Forestry, Syracuse, N. Y., a 1948 graduate of the University of Shanghai, with an M.S. degree from the Carnegie Institute of Technology in 1949.

Andrew G. Lang, Senior Research Engineer, Champion Paper & Fibre Co., Hamilton, Ohio, a 1932 graduate of Miami University (Ohio), with an M.S. degree from Cornell University in 1933, and a Ph.D. degree from the University of North Carolina in 1936.

William G. Lavender, Control Chemist, American Cyanamid Co., Valdosta, Ga., a 1950 graduate of the University of Buffalo.

Paolo Marpillero, Pulp Engineer, Azienda Brevetti Industrial, Milan, Italy, a 1921 graduate of Politecnycal University, Milan.

William D. Miller, Development Engineer, Eastman Kodak Co., Rochester, N. Y., a 1938 graduate of Iowa State College.

William E. Morris, Development Supervisor, B. F. Goodrich Chemical Co., Cleveland, Ohio, a 1933 graduate of the University of Tulsa.

Franz Muller, Work Manager, Wallboard Mill, V. Leitgeb Sage-und Holzfaserplattenwerk, Kuhnsdorf, Austria, a graduate of Realschule und Technische Hochschule.

Richard J. O'Brien, Chemist, E. I. duPont de Nemours & Co., Inc., Deepwater, N. J., a 1949 graduate of the New York State College of Forestry.

Denis J. O'Flynn, Chemist, E. I. duPont de Nemours & Co., Inc., Wilmington, Del., a 1944 graduate of the National University of Ireland with an M.S. degree.

Anthony W. Pomper, Development Engineer, John Waldron Corp., New Brunswick, N.J., a 1948 graduate of Rutgers University.

Edward M. Pyatt, Jr., Chemist, Ball Bros. Co., Noblesville, Ind., a 1950 graduate of Drexel Institute of Technology.

Richard I. Rice, Technical Director, American Coating Mills, Elkhart, Ind., a 1943 graduate of the University of Michigan.

Horace T. Robson, Chemical Engineer, Union Bag & Paper Corp., Savannah, Ga., a 1947 graduate of Massachusetts Institute of Technology.

Paul E. Rogers, Paper Mill Engineer, Scott Paper Co., Chester, P., a 1942 graduate of Cornell University.

Kenneth R. Ross, Student, Cornell University, Ithaca, N. Y.

Willard L. Scott, Chief Chemist, Aluminum Foils, Inc., Jackson, Tenn., a 1941 graduate of Virginia Mechanics Institute.

Liu Shih-chu, Mill Manager, Taiwan Pulp & Paper Co., Shihlin, Taipeh, Taiwan, China, a 1942 graduate of National Chiao Tung University.

Rene Silva, Design Engineer, Southern Paperboard Corp., Port Wentworth, Ga., a 1932 graduate of the Catholic University of Chile.

Roger W. Strauss, Laboratory Technologist, Bauer Bros., Springfield, Ohio, a 1949 graduate of the New York State College of Forestry, with an M.S. degree in 1950.

Robert C. Sturken, Partner, Frank W. Egan & Co., Bound Brook, N. J., a 1940 graduate of Stevens Institute.

Hilding Tyden, Research Director, Svenska Cellulosa A.B.,

FIBREpulper

BY DOWNINGTOWN

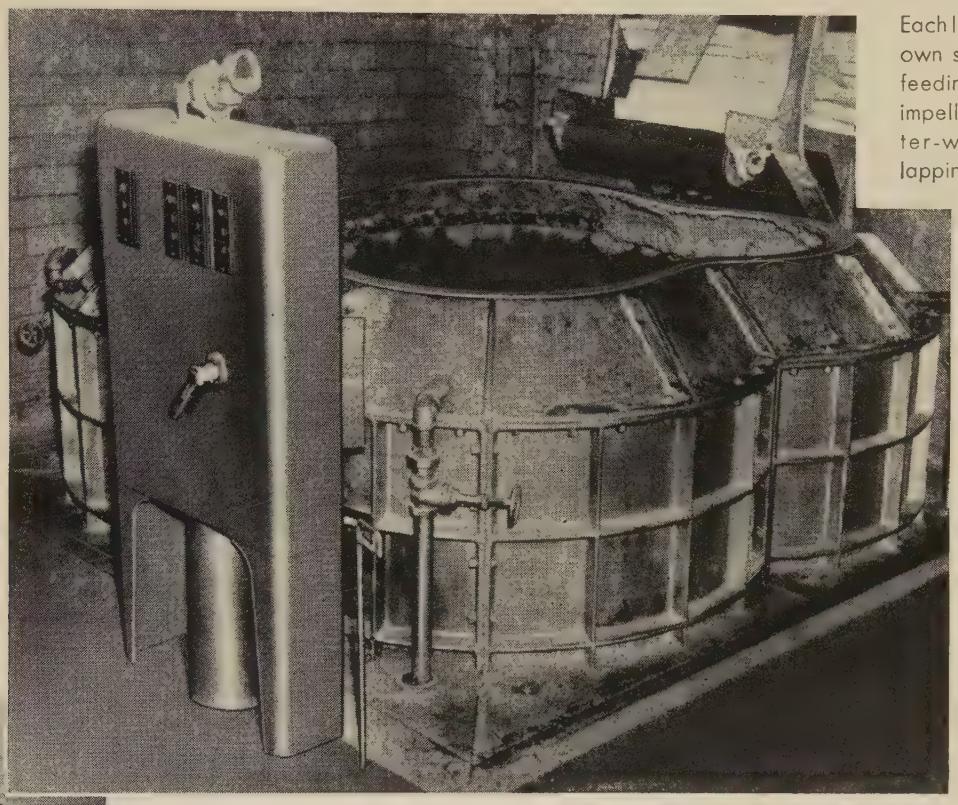
marks major pulping advance

IT'S THE SHAPE

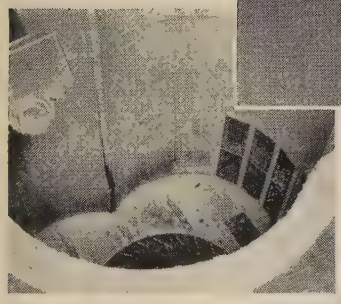
FIBREpulper designed and custom-built for your operating conditions

Here's why

Each lobe develops its own stream of stock, feeding back to the impeller, with an inter-weaving, overlapping pattern.



Operating-floor view of FIBREpulper and auxiliary equipment in large eastern tissue mill.



Internal view of tub, showing rotor and extraction plates.

FIBREpulper being charged with baled pulp from conveyor.

Advantages:

Less horsepower per ton

Shorter pulping period—less hydration—higher freeness

Shorter pulping period also means smaller unit for given tonnage

Easier to "floor plan"

More pulping for your money

PATENTS APPLIED FOR

DOWNINGTOWN MANUFACTURING COMPANY

DOWNINGTOWN, PA.

Pacific Coast Representative: JOHN V. ROSLUND, Pacific Bldg., Portland 4, Ore.

DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY SINCE 1880

Skonsmon, Sweden, a 1926 graduate of Royal Technical University, Stockholm.

William J. Van Akin, Manager of Manufacturing, The Ruberoid Co., New York, N. Y., a 1924 graduate of Rensselaer Polytechnic Institute.

Jan H. van der Meer, Director, Research Institute for the Graphic and Allied Industries, Amsterdam, Holland.

Virgil W. Westdale, Paper Chemist, Burroughs Adding Machine Co., Paper and Ribbon Laboratory, Detroit, Mich., a 1949 graduate of Western Michigan College.

Hiroshi Yeguchi, Chief Engineer, Research Dept., Kokusaku Pulp Mill, Asahikawa, Hokkaido, Japan, a 1939 graduate of Kyoto Imperial University.

Tappi Notes

Henry J. Anderson, formerly of the Marathon Corp., is now in the Promotion Department, Salem Label Co., Salem, Ore.

Eugene Bartlett, formerly of the British Columbia Pulp & Paper Co., is now Sulphite Design Engineer, Powell River Co., Powell River, B. C.

Claes O. Berggren, formerly Student of the N. Y. State College of Forestry is now Paper Chemist for Personal Products Corp., Milltown, N. J.

Richard L. Betts is now Assistant General Superintendent, Paper Mill, Champion Paper & Fibre Co., Pasadena, Tex.

Arthur Biddle, formerly of the Reynolds Metals Co., is now Technical Director, J. M. Frey Co., ink manufacturers of Richmond, Va.

Mrs. Hildegarde M. Buffington has moved from New York City to Sarasota, Fla.

Ducie C. Chads is now Assistant Superintendent, Puget Sound Pulp & Timber Co., Bellingham, Wash.

E. A. Charlton, formerly Consulting Engineer is now Executive Vice-President and General Manager, Central Paper Co., Muskegon, Mich.

Richard G. Cohn is now Bleach Plant Superintendent, St. Regis Paper Co., Pensacola, Fla.

John F. Corwin, formerly of the Borden Co., Chemical Division is now in the Development Department, Koppers Co., Chemical Division, Pittsburgh, Pa.

Paul B. Davidson is now Senior Fellow at the Mellon Institute for Industrial Research, Pittsburgh, Pa.

William P. Dohne, formerly of W. C. Hamilton & Sons, is now Technical Director, Hawthorne Paper Co., Kalamazoo, Mich.

Loren V. Forman is now Staff Director of Pulp Utilization, Scott Paper Co., Chester, Pa.

Charles E. Gehr, formerly Student, N. Y. State College of Forestry is now Project Engineer, Container Corp. of America, Manayunk, Pa.

John S. Hart is now Chief, Chemical Pulping Group, Pulp & Paper Research Institute of Canada, Montreal, P. Q.

Kenneth D. Hay of the Asten-Hill Mfg. Co., has been transferred from Philadelphia to Appleton, Wis.

Frederick C. Holmes, formerly Chief Engineer, Smith Paper Co., is now Sales Engineer, Bird Machine Co., So. Walpole, Mass.

Alex Holstein, Jr., formerly Student, N. Y. State College of Forestry is now in the Engineering Development Department, Syracuse Ornamental Co., Syracuse, N. Y.

Lyle C. Jenness is now Head of the Chemical Engineering Department, University of Maine, Orono, Me.

Arthur H. Lambert, formerly Student, N. Y. State College of Forestry is now Chemist for the Container Corp., of America, Manayunk, Pa.

J. L. Lanford is now Asst. Paper Mill Superintendent, Sonoco Products Co., Hartsville, S. C.

W. P. Lawrence is now Director of Pulp and Byproducts Research, Champion Paper & Fiber Co., Hamilton, Ohio.

E. B. Lewis, formerly of the Howard Paper Mills, is now Research Chemist, Southern Chemical Cotton Co., Chattanooga, Tenn.

Albert T. Maasberg is now Director of Research, Cellulose Products Div., Dow Chemical Co., Midland, Mich.

Frank Makara's correct address is 2451 Webb Ave., Bronx 63, N. Y.

Eric D. MacLaurin is now Director and Secretary, Smith & MacLaurin Ltd., Cartside Mills, Renfrewshire, Scotland.

Parker McIntosh, formerly of Woods Mfg. Co., Ltd., is now Paper Mill Superintendent, Dominion Paper Co., Kingsey Falls, P. Q.

A. D. Merrill is now President, Chemipulp Process, Inc., Watertown, N. Y.

John McWilliams is now Asst. Mill Manager, Byron Weston Co., Dalton, Mass.

John A. Miller, formerly of the Container Corp., of America, is now Superintendent of O. B. Andrews Co., Chattanooga, Tenn.

William P. Nesbitt is now General Superintendent, Howard Smith Paper Mills Ltd., Cornwall, Ont.

Jerry S. Nickerson, formerly Student, University of Maine is now a trainee, Robert Gair Co., Piermont, N. Y.

Clifford B. Pape is now Plant Manager and Technical Director, Dominion Foils (Canada) Ltd., Three Rivers, P. Q.

Lester H. Peterson is now Research Engineer, Consolidated Machine Tool Corp., Rochester, N. Y.

John W. Pontius, formerly of Certain-teed Products Inc., is now with Champion Paper & Fibre Co., Hamilton, Ohio.

Cover C. Porter is now Asst. Manager, Southland Paper Mills, Lufkin, Texas.

Edward L. Powell, formerly Superintendent of the Southern Chemical Cotton Co., is now a Chemical Consultant, 3806 St. Elmo Ave., Chattanooga 9, Tenn.

Ralph B. Reade, Consulting Engineer for the Ruberoid Co., has moved from Joliet, Ill., to Mobile, Ala.

O. K. Ronning, formerly with the Union Paper Co., Skien, Norway, is now Sales Engineer, E. D. Jones & Sons Co., Pittsfield, Mass.

Edward M. Root of the Dilts Machine Co., is now located at 927 Coventry Road, Decatur, Ga.

Fred W. Sanders, formerly of Pillsbury Mills, Inc., is now a Development Chemist for the Eastern Corp., Bangor, Me.

Milton D. Schreiber is now Head of Chemical Research for the Dixie Cup Co., Easton, Pa.

William F. Schroeder, formerly of the Buffalo Electro Chemical Co., is now Technical Service Engineer, National Distillers Chemical Corp., Ashtabula, Ohio.

Charles M. Sigvard, formerly of the Scott Paper Co., is now in the Research Dept., The Celotex Corp., Chicago, Ill.

Thomas H. Smith is now Asst. Director of Research, International Paper Co., Mobile, Ala.

Norton L. Speck, Chemist of the Dixie Cup Co., has moved from Easton, Pa., to Chicago, Ill.

Frederick N. Sprague is now Technical Assistant to the Manager, St. Regis Paper Co., Bucksport, Me.

F. P. Thornton, Jr., is now Vice-President, Stowe-Woodward Co., New York, N. Y.

Claire Turner, formerly Superintendent of the Pollock Paper Corp., is now Sales Engineer for the Appleton Woolen Mills, Appleton, Wis.

B. J. Twisdale, formerly of the Gould Paper Co., is now Chief Chemist, St. Lawrence Paper Corp., Norfolk, N. Y.

R. W. K. Ulm is now Technical Director, San Joaquin Div., Fibreboard Products, Inc., Antioch, Calif.

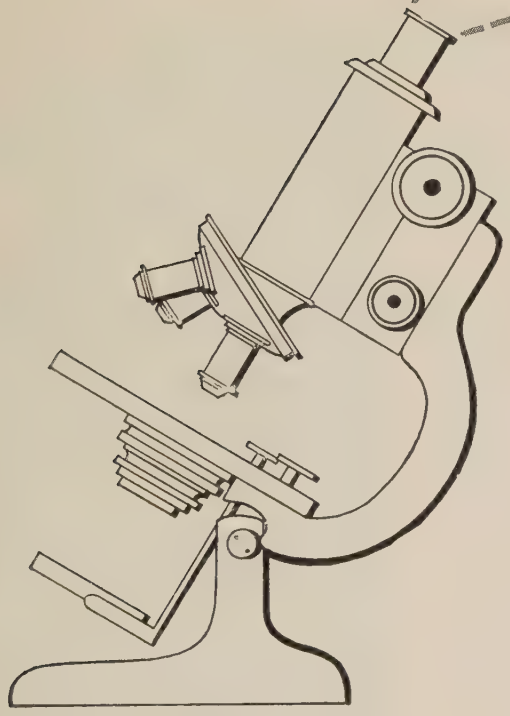
J. L. Van Nort is now Asst. Manager, Engineering Dept., Reliance Electric & Engineering Co., Cleveland, Ohio.

Sam T. Weber is now Asst. Sales Manager, Black-Clawson Co., Hamilton, Ohio.

Raymond H. Wiles is now Asst. Director of Research, International Paper Co., Glens Falls, N. Y.

kill these pests...

Typical slime-forming organisms



with CHLORINATION by W&T

Quality conscious paper mill superintendents know from experience that chlorination, engineered to their stock or white water requirements by Wallace & Tiernan, effectively eliminates such slime-induced troubles as pin holes, slime spots, and poor sheet formation.

Such results — which have saved up to 400 dollars per day in many mills — are possible because chlorination kills the organisms that *cause* slime. It may be used alone on the fresh water supply, or together with chloramines or other corrective chemicals on the white water, for effective slime control in such key spots as the showers, screens, deckers, and at many other points.

Wallace & Tiernan Chlorinators are particularly effective in slime control work because they are especially designed from over 35 years' experience to give low cost, efficient performance.

For a survey on the chlorination needs of your mill without obligation, call your nearest W & T Representative now and start your plant on the road to slime free operation.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

I-36

Industry Notes

D. B. Hatcher has succeeded Charles L. Neely (deceased) as Official Representative of the Plaskon Div., Libbey-Owens-Ford Co., Toledo, Ohio, in TAPPI.

L. J. Smith has succeeded R. W. Shaver as the Official Representative of the Gould Paper Co., Lyons Falls, N. Y., in TAPPI.

H. Ainsworth Harrison has succeeded W. Taylor (retired) as the Official Representative of Cooke & Nuttal Ltd., Horwich, Lancashire, England, in TAPPI.

Francon Harmant has succeeded Ernest Clement as the Official Representative of Papeteries Steinbach & Co., S. A., Malmedy, Belgium, in TAPPI.

John H. Heuer has succeeded Fred Sprague as the Official Representative of the St. Regis Paper Co., Deferiet, N. Y., in TAPPI.

* * *

Recent visitors to the United States have included:

Sten E. Holgersson, Managing Director, Hylte Bruks A/B. Hyltebruk, Sweden; Hans Otter, Engineer, Feldmuhle Papier und Zellstoffwerke A/G., Aberlahustein, Germany; Adolf Benedello, Technical Director, Papierfabrik Kobel, Hagen-Kabel, Germany; Yoshio Koge, Research Director, Jujo Paper Mfg. Co., Tokyo, Japan; and W. O. Hisey, Manager, South African Pulp & Paper Co., Transvaal, S. A.

* * *

Olin Industries, Inc., has purchased a substantial interest in the Harwid Co., Cambridge, Mass., manufacturers of polyethylene film.

* * *

The Black-Clawson Co., Hamilton, Ohio, is now producing magnesium treated gray iron castings under license of the International Nickel Co. The product is called BlaCaloy. Due to the reaction of magnesium upon the carbon constituent of gray iron, the particles of free graphite are converted from flake or stratified form to modules or spheroids. This change of graphitic form overcomes the structural discontinuity and internal notching effects of graphite stratification. It is stronger than gray iron in respect to tensile strength, ductibility toughness, finish, temperability, weldability, and is equally as good in machinability and corrosion resistance as regular high-alloyed gray iron.

* * *

The Japanese TAPPI now has over 1700 members.

* * *

The Swedish Royal Decoration with rank of Commander, Order of Vasa was awarded to Louis B. Calder, President of Perkins-Goodwin Co., at the Swedish Consulate General in New York City on September 28th. This award was made to Mr. Calder for his efforts in improving trade relationship between the United States and Sweden.

* * *

The NOPCO Chemical Co., Harrison, N. Y., now is using polyethylene bags to line its steel drums used in shipping defoamers and other chemicals to paper mills.

* * *

Miss Helen Kiely, Chief Chemist for the American Writing Paper Co., was interviewed recently on the new Holyoke, Mass., Radio Station WREB on a program called Dorothy Drewsen's Dial-log. Mrs. Drewsen is the wife of Pierre Drewsen of the Amherst Blanket Co., a member of TAPPI.

* * *

Major General Alden H. Waitt (Retired) from Chief of the Chemical Warfare Service, has joined R. S. Aries and Associates as Vice-President.

The Atlas Mineral Products Co., 43 Walnut St., Mertztown, Pa., has issued a new Bulletin No. 5-1 on Corrosion Proof Cements. This describes the line of resin, sulphur, silicate, and asphaltic cements.

* * *

Charles Cubbison, Purchasing Agent for the Printing Ink Division of J. M. Huber Corp., has been named Asst. General Plant Manager and Joseph Cavanagh has been appointed Asst. Purchasing Agent for the Ink Division.

* * *

Myers & Addington, Consulting Engineers, 21 East 40th Street, New York, N. Y., have recently been retained by the Gardner Board & Carton Co., to make steam, power, and electrical surveys in their three mills at Lockland and Middletown, Ohio. The object of these studies is to develop a program of modernization of steam and power for purposes of economy and to meet expanding requirements. This firm, which has previously acted as consultants for the Union Bag & Paper Corp., at its Savannah plant, has again been retained by the corporation.

* * *

Raybestos-Manhattan Inc., has removed its New Orleans office and warehouse from Camp St., to 920 Calliope Street. The new facilities will enable the company to serve customers in that area with a more complete stock of belting, V-belts, hose, other industrial rubber products, packings and asbestos textiles. P. L. Andrews has been appointed Manager of its Central District Office in Pittsburgh, Pa. He succeeded R. C. Rice who has retired.

* * *

The Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y., has issued a bulletin (G-72) on its new Shop-Assembled Boiler (B. & W. Integral-Furnace Boiler, Type FM).

* * *

John W. Sale has been appointed General Manager of Paper Manufacturing in charge of the Hummel-Ross Division of the Continental Can Co., at Hopewell, Va., and the Gould Paper Co., Lyons Falls, N. Y.

* * *

The Government specifications relating directly to completed packages and packaging materials in the fiber, paperboard, paper and barrier-film fields include:

Fiber and Paperboard Containers

LLL-B-631	Domestic Corrugated Fiber Boxes
LLL-B-636	Domestic Solid Fiber Boxes
JAN-P-108	Overseas Corrugated and Solid W and V Board Fiber Boxes
JAN-D-111	Overseas Fiber Drums
JAN-P-120	Folding Paperboard Cartons
JAN-P-133	Setup Paperboard Boxes

Barrier Materials and Converted Products

JAN-P-117	Interior Bags
JAN-P-121	Greaseproof Barrier Material
JAN-P-125	Waterproof Barrier Material
JAN-P-131	Water-Vaporproof Barrier Material
AN-B-20	Water-Vaporproof Barrier Material
AN-E-1	Engine Bags
AN-B-67	Interior Bags

These specifications may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

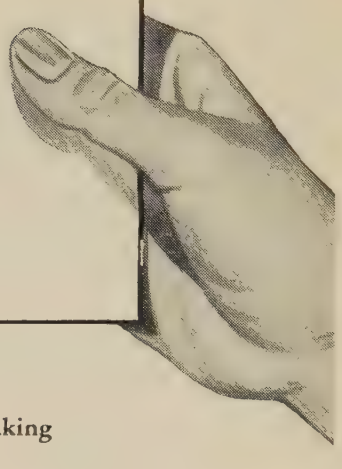
* * *

E. D. Jones & Sons Co., Pittsfield, Mass., has issued a new Bulletin (EDJ-1019B) covering the features, applications and operating detail of the Pulp-Master. Jones reports that 45 units have been sold in the U.S.A., 19 in Canada, and 25 in Europe.

For Paper-Making...

Quality Chemicals

PLUS!



SOLVAY

Trade-Marks SOLVAY and Registered U.S. Pat. Off.

LIQUID CHLORINE

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Ortho-dichlorobenzene • Monochlorobenzene
Methanol • Ammonium Chloride
Formaldehyde

Buffalo Electro Chemical Co., Inc., Buffalo 7, N. Y., has issued a very interesting and instructive bulletin on the Cold Steep Bleaching Process. This process, carried out at high densities provides high bleaching efficiency on Kamyr, Rogers and similar machines. Separate mixing, retention and neutralization facilities are not needed.

* * *

Gottesman & Co., Inc., has moved its offices to 100 Park Ave., New York 17, N. Y.

* * *

Frank W. Egan & Co., has moved its offices to 115 Lincoln Blvd., Bound Brook, N. J.

* * *

W. Stanley Seaman is now associated with Harborside Consolidated Terminal and Warehouse, Inc., 1 Washington Ave., Providence, R. I.

* * *

The New York State College of Forestry, Syracuse, N. Y., has issued an interesting and valuable 42-page booklet on "The Manufacture of Chemigroundwood Pulp from Hardwoods," by C. Earl Libby and Frederic W. O'Neil. Copies may be obtained from the College at $1.00 per copy.

* * *

Dilts Machine Co., Fulton, N. Y., has issued a new bulletin giving general information about the Kohler unwind and winding equipment, the flying paster and flying starter.

* * *

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., has issued a new Bulletin on its Motogear Drives. (Link-Belt Book No. 2247).

* * *

American Cyanamid Co., has granted thirteen postgraduate fellowships and one postdoctoral fellowship for the academic year 1950–1951 in American Colleges.

* * *

Eugene Ward has been appointed General Sales Manager of the Cameron Machine Co., Brooklyn, N. Y. Mr. Ward has been associated with Cameron for thirteen years.

* * *

The Publications Section, U. S. Department of Commerce, Washington, D. C., has issued the following booklets of current interest:

Purchased Items and Purchasing Locations of the Department of the Navy (31 pages—15 cents).

Production Allocation Manual (83 pages—45 cents).

Military Procurement (46 pages—25 cents).

New International Paper Co. Mill at Natchez, Miss.

The first dissolving pulp mill in the South designed to employ a new process for producing dissolving woodpulp used in the manufacture of rayon and other synthetic products will be opened at Natchez, Mississippi, by the International Paper Company.

For the first time in the manufacture of rayon pulps, hardwoods instead of softwoods will be used in the new process, which is based on the sulphate (kraft) process instead of the traditional sulphite process used hitherto. The mill, operated by the Southern Kraft Division of International Paper Company, will have a capacity of 300 tons a day, or an annual capacity of 100,000 tons. This output will increase by 13% the present estimated North American production of rayon

J. T. Peninger, agent of the new Natchez mill, in front of the machine room

The Mill Itself

International Paper Company's new rayon pulp mill at Natchez, Miss., is designed to produce all grades of dissolving pulp used by manufacturers of rayon yarns, cellophane, plastics and similar products.

Using entirely new methods of purification and bleaching, it uses the sulphate process for producing dissolving woodpulp. The significance of this is the development of the extensive use of hardwoods for making dissolving pulps for the manufacture of rayon yarns.

The mill will have an annual capacity of 100,000 tons of rayon pulp, increasing the present estimated North American output of dissolving pulp by about 13%.

This new process combines the technical experience of International Paper Company and its Canadian subsidiaries. It was developed by the Company's Southern Kraft Division with the technical advice of Industrial Cellulose Research Limited, a research affiliate of Canadian International Paper Company, which operates at Hawkesbury, Ontario, one of the world's foremost research and control centers for developing new techniques in the manufacture of dissolving woodpulps. The Canadian company has had thirty years of operating experience in this field. Its Kipawa mill at Temiskaming, Quebec, started operation in 1920 and was the first mill in the world designed and equipped specifically for the production of these specialized pulps. Through expansion of Kipawa and the conversion of two other pulp mills to dissolving grades, Canadian International's dissolving pulp capacity has now reached 225,000 tons a year. All of this, plus the 100,000 tons from the new mill at Natchez, will be sold through an affiliate of Canadian International, Riordan Sales Corporation Limited.

Natchez Voted for Mill

On Jan. 11, 1949, the people of Natchez voted to authorize a city bond issue of $300,000, the proceeds to be used to purchase 1000 acres of land for the mill site and railroad right-of-way.

The vote was unmistakably an act of welcome. More than 97% of those who voted were in favor of the mill. The Company greatly appreciated this overwhelming vote of confidence.

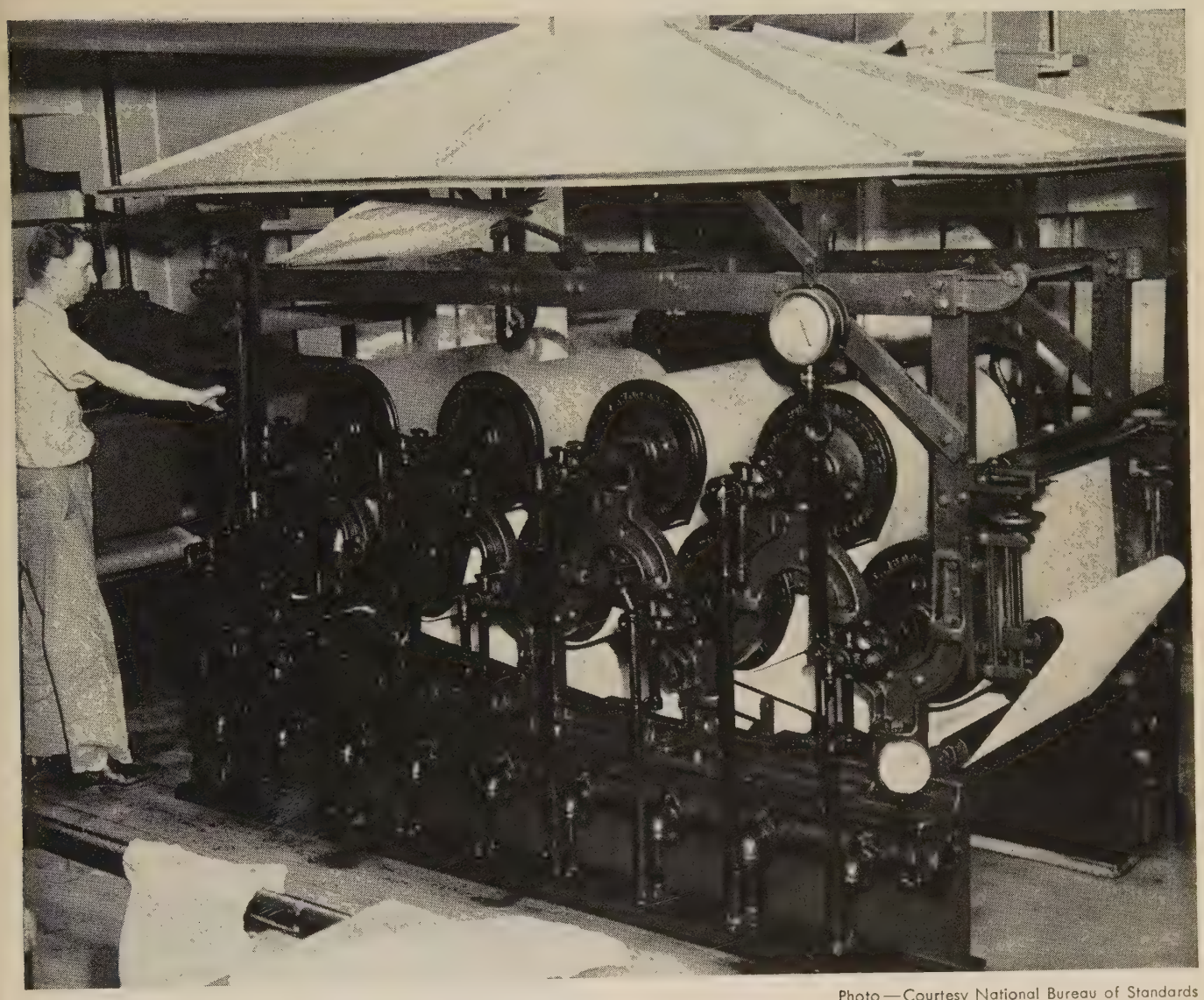
The City of Natchez was never called upon to undertake this financial burden as the Company decided to assume itself the entire cost of purchase and construction.

What the Mill Means to the Community

First of all, the new mill means new jobs in Natchez. The payroll at the mill will probably run in the neighborhood of $3,500,000 a year, and it is expected that about 70% of this amount will be spent locally by the workers.

When the mill is in full operation, Southern Kraft Division

THE
smallest
ASTEN Dryer Felt



Photo—Courtesy National Bureau of Standards

Dryer Felts don't come much smaller than this one on the dry end of a semi-commercial 29" Fourdrinier

ASTEN-HILL MFG. CO.
PHILADELPHIA, PENNA.

ASTEN-HILL, LTD.
VALLEYFIELD, QUE.

G. G. Boyd, Jr., Superintendent of the Woodyard, checks logs on the conveyor to the hydraulic backers

expects to spend about an additional $2,750,00 a year with railroads, trucking concerns and other haulers, as a result of the mill's establishment. This means additional security and income for the employees of such enterprises.

(Southern Kraft Division already has an investment of over $100,000,000 in the South and an annual operating payroll of $38,388,732. In 1949, it paid about $31,836,000 for pulp wood, of which amount $10,600,000 was for payment of rail freight.)

Where Does the Wood Come From

Trees are by far the greatest of the Southern crops in acreage today. Approximately 183,000,000 acres are covered with commercial forest. (The second largest crop acreage is corn, with less than 26,000,000 acres.) The South, with its wealth of sunlight and rain and fertile forest soils, now accounts for 40% of the total U. S. production of lumber and 50% of the total U. S. production of pulpwood.

In 1949, 93% of all the wood used by International Paper Company came from farmers and private woodland owners, and the Company expects to spend about $35,000,000 this year in the South in buying pulpwood.

About Conservation

The Southern Kraft Division of International Paper Company maintains an organization of more than 135 foresters. It has a special force of conservation foresters whose main responsibility is to work with the people of the states to which they are assigned in every constructive effort which will encourage good forest management.

During 1949, these conservation foresters delivered messages on conservation through exhibits and meetings of various kinds to 992,895 people. They had 2784 personal contacts with pulpwood producers, woods laborers, public foresters, and others. Supplying forestry information, they visited owners of 310,377 acres of forest land. They helped mark for cutting the timber on 1100 privately-owned forest properties involving 79,980 acres of forest land.

During 1949, the Company built 156.6 miles of new roads and maintained 2100 miles as part of its fire control work throughout the South. Nearly 6000 miles of firebreaks were ploughed in 1949 by the Company.

During the 1948–1949 planting season, the Southern Kraft Division distributed more than 2,600,000 seedlings for planting on the lands of others and set out 6,000,000 on its own lands.

At the end of 1949, International Paper Company and Southern Kraft Timberland Corporation owned or controlled 2,416,484 acres of woodlands—of which 237,602 were in Mississippi. The Company removed 307,000 cords of pine and 131,000 cords of hardwood from its own lands in the South during 1949; the net increase, due to growth only was 1,100,000 cords.

The Company's forest lands in Mississippi are among the best managed in the United States. In 1949, forest fires on company lands in the state were held to less than 0.8% of the total acreage. The figure for unprotected lands was $52^1/_2$ times as great.

Rayon

From the viewpoint of the great and growing rayon industry in North America, the Natchez project means that the production of dissolving woodpulp will be sufficient to meet the increased raw material demands from new rayon capacity.

From the viewpoint of the owners of timberland acreage, whether large or small, it will mean a better balance of growth, more efficient management, and increased sales of wood. To be able, henceforth, to cut the hardwoods along with the softwoods will mean that not only can forest owners earn money on their hardwoods, but also that the resultant thinning will promote good growth in the remaining stands.

The new process making this possible is based on the sulphate or kraft process instead of on the sulphite process used traditionally for making such pulps.

At the mill, the wood arriving from the timberlands is cut into chips, and cooked, bleached, washed and pressed into sheets of pulp that look like blotting paper.

These dissolving woodpulps are shipped to the manufacturer for processing into rayon, plastics, cellophane and allied products.

The most dramatic recent development in the rayon industry is the rise in the use of viscose high tenacity yarns in the manufacture of tire cords for mother vehicles. Since the commencement of the commercial application of rayon in tire fabrics only as recently as 1939, when 9,000,000 pounds were produced, the consumption of rayon tire cords has grown to 282,000,000 pounds in 1949. The 9,000,000 pounds produced in 1939 represented only 4% of the total tire cord used in the United States during that year. The 282,000,000 pounds produced in 1949 (which includes a comparatively small poundage of nylon) represented 71% of the total tire cord used in the United States last year. Production during the fourth quarter, 1949, showed a further increase, and by that time rayon tire cord (including some nylon) had taken over 81% of the tire cord business.

Liquor storage tanks

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CORN PROCESSING DIVISION

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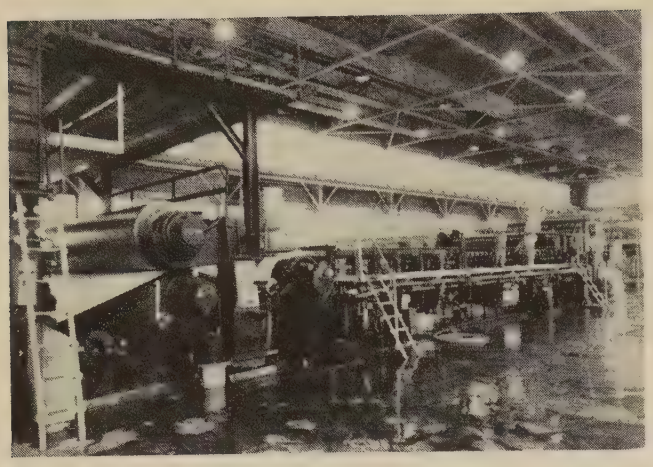


Fourdrinier section of the pulp-drying machine installed at Natchez

In 1937, the National Resources Committee classed rayon along with the telephone, automobile, airplane, motion picture and radio as one of the six most outstanding technical achievements of the Twentieth Century. And by the end of 1949, the United States was producing about 1,000,000,000 pounds of rayon yarns a year.

In the viscose process for making viscose rayon and cellophane, the dissolving woodpulps are first steeped in caustic soda and then squeezed to remove excess liquid, A shredding machine gently crumbles these moist sheets, and the crumbs are allowed to age in steel containers. Afterward, they are placed in huge rotating churns, where carbon disulphide (obtained from coke and sulphur) is blended with them to form an orange-colored substance called "cellulose xanthate."

Caustic solution is then added to the xanthate to form a honeylike viscous liquid. This liquid is transferred to ripening tanks where it is filtered to remove all foreign matter.

For the manufacture of viscose rayon, the solution is then extruded into an acid bath through microscopic holes in spinnerets of precious metal. As each jet hits the surface of the bath, it solidifies immediately into threads of rayon.

For the manufacture of cellophane, the ripened viscose solution is piped to huge casting machines, about 100 feet long. The golden colored liquid enters a closed trough-shaped hopper, at the bottom of which is a narrow slit. The lips of this slit are of very hard metal, ground to a high degree of accuracy and adjustable to the ten-thousandth of an inch. As the solution is squeezed through these knife edges, it enters a bath of dilute sulphuric acid which almost instantly coagulates it into sheets of transparent cellophane film.

Selection of Natchez

Natchez was selected because of the many facilities available and its close proximity to 250,000 acres of Company-owned land. It is served by three railroads—Illinois Central, Missouri Pacific, and Mississippi Central—the mighty Mississippi River, and leading state highways. The mill site and railroad rights-of-way occupy 1000 acres located on St. Catherine Creek approximately three miles southwest of the city and the Mississippi River. On March 3, 1949, ground was first broken and construction started on the most modern mill in the United States, and it was completed May 12, 1950, providing another ultramodern use for Southern forest products.

Hardwoods, for which there has not been much practical use as pulpwood, will be used almost exclusively in the manufacture of dissolving pulp, which is used in making plastics, rayon yarns, cellophane, and other allied products. The production capacity of this first unit is 300 tons daily (or 100,000 tons annually). Two additional units can be added at a later date when demands for more production are pressing.

Personnel at Natchez

The supervisory staff of the mill includes the following: Mill Manager, I. Y. East; Production Superintendent, E. E. Ellis, Jr.; Technical Director, J. M. Van Hoose; Utility, Maintenance & Engineering Superintendent, E. C. Guidroz; Paper Mill Superintendent, R. D. Jordan; Pulp Mill Superintendent, Emmett Jones; Chief Chemist, C. T. Hightower; Plant Engineer, T. C. Payne; Master Mechanic, Fletcher Poulan; Power Plant Superintendent, B. E. Lynd; Chief Electrician, C. W. Sawyer; Personnel Director, G. W. Biron; Safety Director, Frank Holland; Woodyard Superintendent, G. G. Boyd, Jr.; Wood Procurement Superintendent, D. V. Logan; Division Forester, A. K. Dexter; Mill Agent, J. T. Peninger; Purchasing Agent, J. W. Oenalager and Chief Accountant, B. F. Ritchie.

Equipment in Natchez Mill

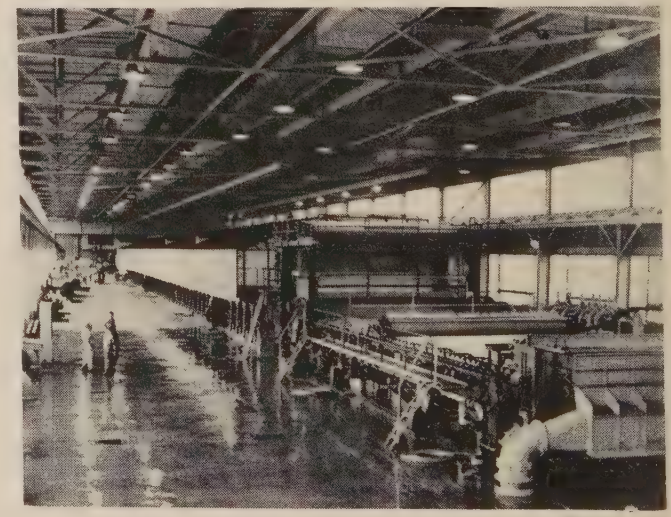
A resumé of the system and equipment used at the Natchez Mill for producing dissolving pulp that can be used in the production of paper, rayon, viscose, etc., follows.

The wood to be used at the Natchez Mill will be southern hardwoods consisting mostly of gums with some bay, poplar, etc. The hardwood will be delivered to the mill by trucks and railroad cars. It will be unloaded by cranes and by hand, depending upon the type of railroad car, to the storage yard or to the water conveyor transporting to the process. Wood from storage likewise will be handled by cranes to this water conveyor, thence to process.

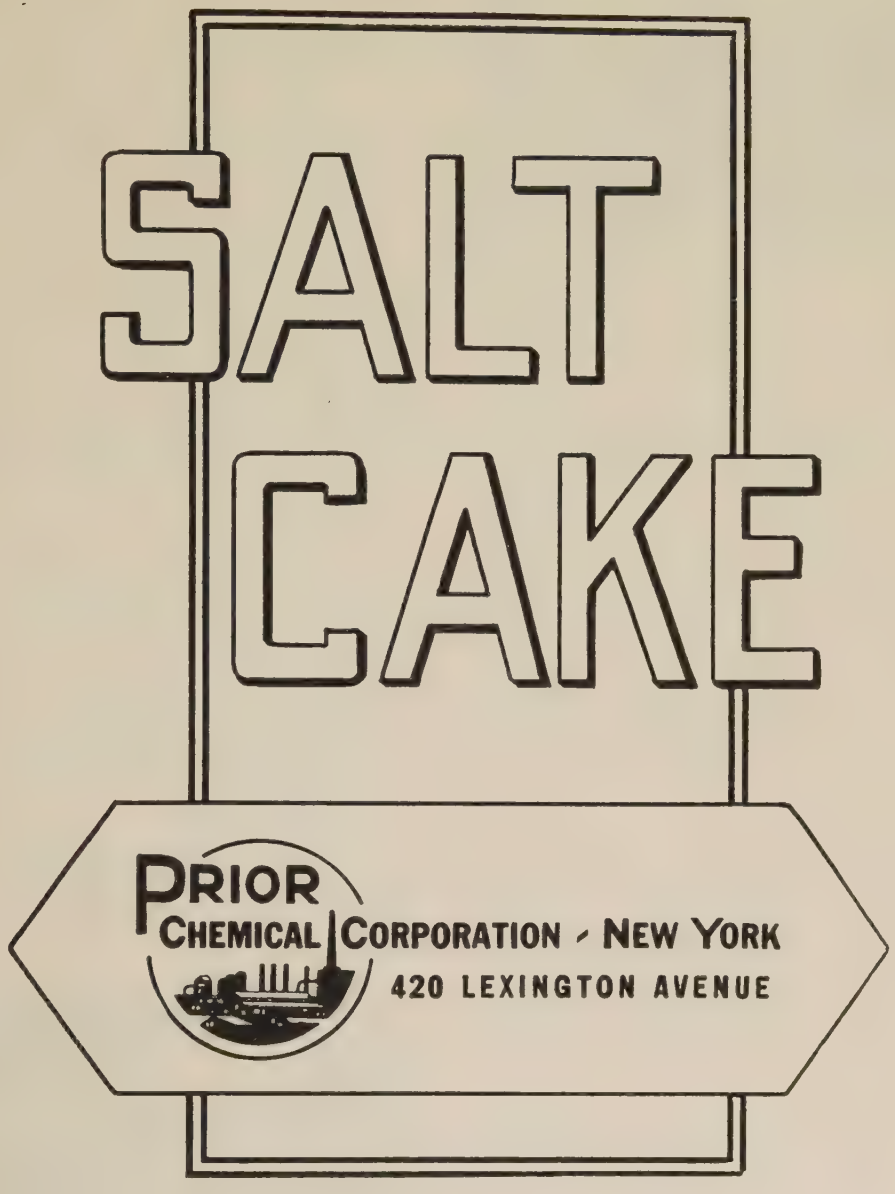
An escalator conveyor removes the wood from the flume and delivers it to various mechanical conveyors for feeding two specially designed hydraulic barkers. These barkers, built by the Worthington Company, were developed by Worthington Engineers working with the Engineering Department of Southern Kraft Division of International Paper Company. The barkers are designed for 1200 lb. working pressure and will handle wood pulp logs approximately 5 feet in length.

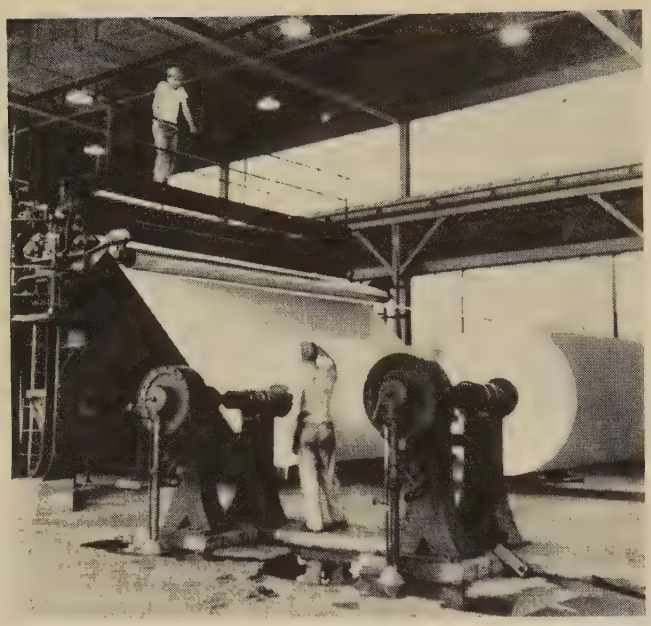
After the barkers, the wood is sorted and the acceptable logs are chipped by a multiknife chipper. The chips are screened and the oversize chips are rechipped to acceptable size The accepted chips are thence conveyed by belt conveyors to multiple chip silos for storage ahead of the digesters. These tile-constructed chip silos were built by Stebbins Engineering Company, and the discharge mechanisms are plate feeders furnished by Link-Belt Company.

There are eight carbon steel digesters 13 feet in diameter by 57 feet in length, these being furnished by A. O. Smith, and lined with carbon brick by Stebbins Engineering Company. These digesters are loaded by belt conveyor directly from these silos. The chips are weighed for accurately determining the chip charge to each digester. A shuttle conveyor arrangement permits the loading of the various digesters, as required by the cycle. The chips are cooked in these digesters, which have circulating and auxiliary equip-



Pulp-drying machine seen from the wet end


SALT
CAKE
PRIOR
CHEMICAL CORPORATION - NEW YORK
420 LEXINGTON AVENUE



Rolls of dissolving wood pulp are fed to a Beloit heavy-duty cutter

ment furnished by Electric Steel Foundry Company. After cooking, the charge from the digester is blown into a blow tank and from there, the pulp is washed over the line of Oliver United Filter brown stock washers.

After washing, the pulp is screened on Waterous flat screens furnished by Montague Machine Company and is then thickened and further washed on deckers which discharge the stock into Kamyr storage chests. From these stock chests the pulp is pumped to a multistage Kamyr bleach plant employing both low-density and high-density stages with vacuum washers between stages. The bleached pulp is screened on Waterous flat screens and again thickened and further washed on Oliver deckers. These deckers discharge into Kamyr type stock chests which furnish the pulp drying machine. The furnish to the machine, after passing through jordan refiners, is further cleaned by vortraps just ahead of the headbox of the Beloit fourdrinier pulp drying machine.

This Beloit machine of 220 inch width is equipped with enclosed mechanical gear drive provided with separate hypoid units at each station and designed for a maximum speed of 600 f.p.m. with a line-shaft speed of 500 r.p.m. The headbox of the machine is of special design, the distributor is constructed of stainless steel, the slice and pond sides of special cast brass and the apron board monel covered. The press section is of the Beloit vertical type, complete with felt stretchers and automatic felt guides and hand guide equipment. The drier section consists of 78 paper driers, 60 inches in diameter. The drier section is divided into five parts, each complete with felt handling equipment, and completely covered by a 302-foot hood with seven 66-inch exhaust uptakes installed. The hood is constructed of Johns-Manville Transite in a removable panel form. The driers are of the latest Beloit high-pressure design and suitable for operation up to 125-lb. steam pressure. A Ross-Grewin air system will furnish filtered air to the driers. The reel is a Beloit heavy-duty kraft reel having a 36 inch diameter constant speed reel drum, and provides for 84 inch roll diameters.

After drying on this machine, the rolls of pulp are cut into the required sheet size by a Beloit heavy-duty cutter, built for high-speed operation, complete with Beloit slitters. From the cutter the sheets are handled on a layboy and conveying system to three Baldwin 600-ton pulp baling presses. In this conveyor system the bales of pulp are weighed, wrapped, and tied. Storage room is provided and equipped with overhead cranes for handling and storing of the bales from which it will be loaded directly from car level height loading platforms into railroad cars for shipment.

The hardwood bark after crushing will be conveyed by a Hofft feeder to a Babcock and Wilcox bark burning boiler.

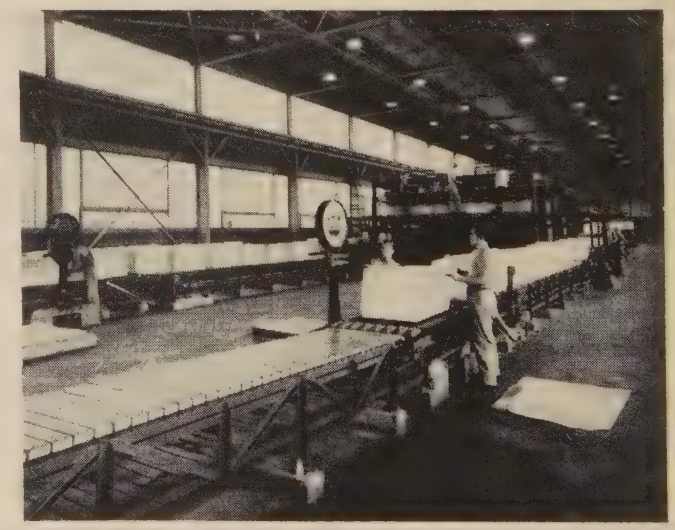
The spent black liquor from the brown stock washers will be evaporated by a set of Goslin-Birmingham long tube vertical evaporators. The evaporated black liquor will be burned in two B & W soda recovery boilers. The smelt from these units goes to dissolving tanks and is then pumped to the continuous Dorr causticizing equipment where it is clarified and causticized to produce sulphate cooking liquor. The lime mud from the caustic plant will be reclaimed by burning in a 10 ft.–6 in. by 175 ft.–0 in. rotary sludge lime kiln lined with Mexico refractories. It is fired by a Coppus fan-mixed gas burner. The kiln furnished by Traylor Engineering Company is driven by a high-torque, two-speed 75 hp. electric motor. The flue gases from this kiln will pass through a lime scrubbing system, for dust collection, to a 150 ft. by 7 ft. 6 in. concrete stack with a completely independent full-height brick lining.

The water treatment facilities, which provide for softening and filtering, will treat about 30,000,000 gallons of water per 24 hours. The well system was installed by the Layne Central Company, Jackson, Miss., while the water treating plant was furnished by Infilco, Inc.

For fire protection the Chicago Bridge and Iron Works built a 100,000 gallon, 125-foot ellipsoidal tank supported by pipe columns. This tank will service an automatic sprinkler system placed in all combustible places in the mill. The wood yard and other outside areas are adequately protected by strategically located hose houses. Two 2500 gallon-per-minute pumps, one motor driven and one turbine driven, are connected to the system for immediate use in an emergency.

The power plant has two General Electric turbo-generators, one 7500 kw. and the other 6000 kw. The electrical generation and distribution is at 4160 volts. The power plant switchgear, transformer load centers, and high voltage motor control were furnished by Westinghouse Electric and Manufacturing Company, with General Electric Company furnishing the motors and low-voltage motor controls.

The boiler room consists of one 150,000 pound per hour bark burning boiler and one 150,000 pound per hour, gas-fired boiler. Each boiler is identical except that one unit has a Detroit Rotograte stoker under it for the purpose of burning both wood refuse and gas, while the other is for gas fuel only. The wood refuse is furnished to the stoker by a Hofft feeding machine from a bark storage bin. Both boilers are designed for an operating pressure of 600 pounds with various components such as a continuous type loop tube



Sheet pulp is weighed before being pressed and baled for shipment

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- ALBA C Pasting Starch
- MAXECON Starch # 604

CORN PRODUCTS REFINING COMPANY 17 Battery Place New York 4, N. Y.

Sheets of dissolving wood pulp are fed to the 3-ton pulp baling press

economizers, superheaters, and air heaters. The induced draft fans for each boiler were furnished by the American Blower Corporation and the forced draft fans by B. F. Sturtevant Company. Natural gas to be used as fuel for these two boilers is furnished from a local gas field in that area.

The recovery room has two modern 250-ton Babcock and Wilcox Tomlinson chemical and heat recovery units. Evaporated black liquor is burned in these two furnaces, equipped with superheaters and economizers, and the steam generated at 600 pounds per square inch is utilized throughout the mill. The recovery furnace flue gases pass through the Koppers electric precipitators for removing chemicals and reducing odor and contamination to the air, and thence through a 300-foot brick and concrete chimney into the atmosphere. This chimney was constructed by the Rust Engineering Company, Pittsburgh, Pa.

The main office is a two-story, brick, concrete and steel structure. The floors are covered with plastic tile, and the building is completely air-conditioned. The offices of the Mill Manager and his staff, the Mill Agent, Purchasing Agent, Accounting Department, Personnel Department, Timekeeper, and the Woodlands Department are to occupy this building.

The utility building is a two-story structure of brick, concrete, and steel. Part of the second story of this building will be used for offices for various department heads, while the supply house will use the balance for storage. The first floor houses the cafeteria, first aid, laboratory, locker and bathrooms, supply house, and maintenance shops. The cafeteria, first aid, and laboratory are constructed with walls of glazed tile, and air-conditioned. These departments are very modern and completely equipped. The laboratory has a constant humidity room. The machine shop housed in this building is modern in every respect and is equipped to handle almost any type of machine work.

The mill area proper, consisting of approximately 540 acres, is fenced with steel cyclone fencing. The entire site is graded properly to take care of the necessary drainage and eliminate erosion of the peculiar type soil found here.

The wood yard area covers approximately 13¾ acres and is illuminated by a total of ninety-six 1500-watt floodlights mounted on eight 75-foot steel towers.

The communication system for this mill is an automatic telephone exchange, operated on 24 volt d.-c. current. This exchange also handles the code calling system throughout the mill.

OBITUARIES

Simeon Richard Holmes

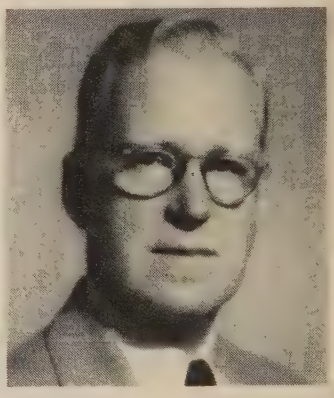
Simeon Richard Holmes, Research Chemist at the Gardner Board & Carton Co., Middletown, Ohio, died on Wednesday evening, Oct. 11, 1950, from a heart attack.

Mr. Holmes was born in Coryville, Pa., on April 11, 1908 and graduated as a chemical engineer from the University of Cincinnati in 1933. From 1929 to 1935 he was a laboratory assistant for the Bekett Paper Co., in Hamilton, Ohio. He joined the Gardner-Richardson Co., in 1935 and continued with this company until his death, with the exception of 1941–1946 when he was an officer in the United States Army.

Mr. Holmes was a member of the Technical Association since 1948 and was Secretary of the Ohio Section in 1948–1949. He was a member of the Section Executive Committee at the time of his death. He resided in Cincinnati, Ohio.

Alvin H. Johnson

Alvin Henning Johnson died Sept. 30, 1950 of a heart attack in his home, 175 Park Ave., Mt. Vernon, N. Y. Mr. Johnson was born in Brooklyn, N. Y., on Sept. 9, 1897 and graduated as a mechanical engineer from Stevens Institute of Technology in 1921.



Alvin H. Johnson, Chairman of Mill Design and Economic Aspects Committee

He became a sales engineer for the Hyatt Roller Bearing Co., in 1921. In 1923 he became production and service manager for the Lanton Auto Equipment Co., and in 1924 joined the consulting engineering organization of Karl A. Lefren in New York City. In 1929 he became associated with Frederick Wierk in the consulting firm of Johnson & Wierk in New York. In 1940 this partnership was dissolved and he continued his consulting practice under his own name until his death. As a consultant he was identified with the construction of pulp and paper mills in Brazil, China, and Guatemala as well as in several states. With Mr. Wierk he built the mill of the National Container Corp., at Jacksonville. His most recent accomplishment was work with the Calcasieu Paper Co., at Elizabeth, La., which was publicized in the trade magazines.

Mr. Johnson was Chairman of the Mill Design and Economic Aspects Committee of the Technical Association of the Pulp and Paper Industry and was scheduled to participate in the TAPPI Engineering Conference at Cincinnati on Monday, following the day of his death. At the conference R. A. Packard presented a fitting eulogy to his memory while the conference stood for a period of respectful meditation.

Surviving are his widow Eleanor Ives Johnson, a daughter Barbara Ives, and his mother Mrs. Bror Albert Johnson, all of Mt. Vernon. On October 8, Dr. Nathaniel Holmes Ives, father-in-law of Mr. Johnson died at Lawrence Hospital in Bronxville, N. Y.

RECENT BOOKS

Pulp and Paper Manufacture. Vol. I. Preparation and Treatment of Wood Pulp. J. Newell Stephenson, Editor in Chief. McGraw-Hill Book Co., New York. 1950. Cloth 6 × 9, 1043 pages. Illustrated. $10.

At last the first volume of the new series of textbooks on the manufacture of pulp and paper has appeared. Since 1921, through three editions the first series, to the time of over 30,000 copies has been serving the industry as an encyclopedia of manufacturing methods and elementary technology. The first series came into being as a result of a widespread need of texts for vocational training. In fact, correspondence schools were established to meet the needs of the industry everywhere. In the early days these texts were issued to students in separate chapter booklets. A satisfactory examination had to be passed before the succeeding chapter was issued.

The revisions of the first series were relatively minor because of book production problems. Finally, the old series was found to be shoddy in contrast to the dynamic and advancing subjects that they encompassed. The demand for a new and up-to-date series grew louder and louder until the present series was brought into being.

It is probably needless to attempt to review the new series other than to state that the Editor—the one and only J. Newell Stephenson of Gardenvale, P. Q., took a fresh start and with approximately the same chapter headings, had the new text written by present-day authors who not only know the state of the art but have a good inkling of what is ahead.

For the record let us say that Volume I with its 1000 or more hefty pages covers the Structure of Pulpwood, Its Preparation for Pulping Mechanical, Sulphite and Alkaline Pulps (the reviewer recently took the Editor to task for forgetting to include Semichemical Pulping and was informed that the Editor will have this subject adequately treated in the subsequent volumes), Treatment of Pulp, Bleaching and Testing of Pulp.

The chapter authors are of first rank and have done a wonderful job. Others are working on Vols. II, III, and IV, and will produce a set of texts unexcelled by any other industry—a real monument to a great basic industry.

R. G. M.

The Economics of the Printing Ink Industry. By Robert S. Aries, Polytechnic Institute of Brooklyn, and Anthony Nickolaus, Sinclair & Valentine Co., New York, Chemonomics, Inc. 1950. Paper-bound, $6^1/_2$ × 9, 108 pages. $5.00.

This is the report of an industry survey by the authors and include such subjects as: History of ink manufacture; firms in the field; raw materials; manufacturing processes; character of the product; effect of the industry on related industries such as paper manufacture, technical developments, and future outlook of the industry.

Encyclopedia of Chemical Technology. Edited by Raymond E. Kirk and Donald F. Othmer, Polytechnic Institute of Brooklyn. Vol. 5. The Interscience Encyclopedia. New York. 1950. Cloth $7^1/_2 \times 10^1/_2$, 992 pages. $20.

This is the fifth in the set of ten volumes constituting the Encyclopedia. A review of Vol. 4 appeared in *Tappi* (May, 1950). Individual volumes are not for sale by the publisher. Subscriptions are being accepted only for the entire set of ten volumes.

The fifth volume begins with the names of materials having the prefix di-, such as diacetone alcohol and, strangely enough even in these trouble times, ends with explosions (gaseous). Included in the volume are such subjects as: dielectrics, diffusion, drying, dust engineering, dyes, electrochemistry, electronics, electrostatic precipitation, emulsions, enzymes, and evaporation.

The authors of each section are authorities who supply the essential information concerning their specialty.

Subscriptions to the ten volumes of the Encyclopedia may be made through *Tappi*.

Forest Products Research Guide. 4th Ed. Prepared by the Standing Committee on Products and Research, National Lumber Manufacturers Association, Washington 6, D. C. 1950. Paper-bound, $8^1/_2$ × 11, 340 pages. $5.00.

This comprehensive reference to the research being done on paper, lumber, and other forest products, is the only one of its kind in existence. It contains a listing of the type of research which has been done and the names of the organization, individual or other agency known to have carried out work in the field listed. 13,400 projects or programs of 2680 organizations are mentioned. These include many foreign as well as domestic references.

The preparation of the Guide represents a tremendous job of classification and indexing. The National Lumber Manufacturers Association is to be commended for preparing this very important guide to the research worker in forest products. It should do much to reduce duplication of effort. We have but one minor criticism: The title of the book should appear on the backbone so that it can be readily located among other books on a shelf.

Copies of books reviewed in this issue may be obtained from the Book Department of the Technical Association of the Pulp and Paper Industry, 122 East 42nd St., New York 17, N. Y.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Pacific

The seminar for advanced study, sponsored yearly by Pacific Section was held Sept. 11 and 12, 1950 in Portland and repeated on September 14 and 15 in Seattle.

The lectures this year were given by Dr. J. A. Van den Akker, Head of the Physics Department at the Institute of Paper Chemistry, on the subject of The Application of Physics to the Processes of Pulp and Paper. About twenty-five technical men attended the sessions in both cities.

The subject matter of Dr. Van den Akker's two day seminar could be listed under two headings: "The Optical Properties of Paper," and "Color," with one day being devoted to each.

Following his introductory remarks concerning the nature of light and a brief review of the fundamental characteristics of reflection, refraction, dispersion and diffraction, Dr. Van den Akker discussed the subject of light sources suitable for optical experimentation. Illuminants A, B, and C, as settled upon at the 1931 meeting of the ICI, were described. The use of the photoelectric cell in making photometric measurements was then considered. It was pointed out that in general the interpretation of data obtained by use of the photocell involves, for other than monochromatic light, the integration of an expression containing both the optical characteristic of the subject studied, and a "continuously weighted factor."

The latter is a combination of the spectral characteristics of the light source, the spectra absorption and transmission properties of all optical components employed, and the spectral response characteristics of the photocell. An example was considered in which the transmission curve of a colored solution was to be determined.

Some of the characteristics of magnesium oxide as a reflectance standard were described. It was shown that although the absolute reflectance of the oxide is about 0.97, the reflectance as measured using the 45–90° illumination-viewing geometry is 1.00. A review of the various methods of forming suitable magnesium oxide standards was given.

The remainder of the first day was very profitably used for a discussion of the Kubelka-Munk theory as applied to paper. The derivation of the basic Kubelka-Munk equation was performed in a manner leaving little to be desired in the way of clarity and ease of following. The direct applicability of the theory to problems of reflectance, opacity, transparency, and color was clearly shown. The point was stressed that while the equations of the Kubelka-Munk theory may appear involved, their application to practical laboratory and mill problems is direct and rapid, usually taking the form of tables, charts, or graphs. The additive character of the scattering and absorption coefficients of the various components of paper was cited, whereby the optical properties of a paper can in large measure be predicted if the above coefficients are known for the pulps, fillers, dyes and other materials used in the paper furnish.

The second day's discussion, on color, opened with a description of color matching by mixtures of light of the three primary colors; red, green, and blue. A device was demonstrated in which the three primaries could be combined in any desired proportion on a ground glass screen. Color perception by the eye was described in relation to the ICI standard observer. The use of the Hardy "selected ordinates" method of obtaining tristimulus values from spectrophotometer data was discussed.

The chromaticity curve was diagrammed, and the color characteristics of dominant wavelength and purity were related to it. The combining of colors, the determination of complementary colors, and the perceptive characteristics of the various types of colorblindness were shown on the diagram. Numerous references were given, for further study of the subject.

Throughout the course of the seminar, Dr. Van den Akker showed a complete familiarity with, and mastery of, the subject at hand, acquired during many years of work in the field. Equally apparent was an ability that cannot be acquired but must be classed as a natural gift. It may be called the ability to teach.

D. L. Shinn
Crown Zellerbach Corp.
Camas, Wash.

New England

The New England Section met at the Red Lion Inn, Stockbridge, Mass., on September 29. About 80 members attended.

Francis L. Simons of Crane & Co., Dalton, Mass., gave a progress report on his work dealing with the use of direct dyes in coloring fibers to determine microscopically the degree of beating and the differentiation between thick-walled and thin-walled fibers.

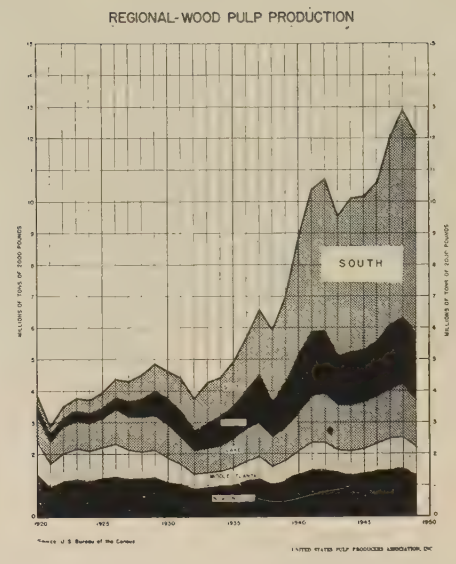
Edwin Cowles, President of the Cowles Co., Cayuga, N. Y., discussed the Cowles Knifemill. Mr. Cowles said in part:

"The conception of the Knifemill occurred about twelve years ago. The thought was: Instead of grinding paper fibers more or less at random between bars or roughened surfaces with accompanying hydraulic and other power losses of great magnitude, why not pick up the fibers by stapling them on an advancing knife edge and then treat them by the proper engagement of this fiber-carrying edge with a stationary member.

"The reasoning was that such a knife member would advance through stock with an absolute minimum of turbulence and power loss and that by locating accumulations of fibers on such knife edges there would be positive assurance of placing the fibers just where the action was taking place.

"It seemed best to accomplish an action which would be comparable to that of a pair of shears. The thought was that sharp edges and sufficient pressure would cut the fibers in two to accomplish a result similar to that of a jordan with sharp tackle and the plug set up hard but without the great waste of power which takes place in a jordan. It was further reasoned that with lighter pressures and perhaps heavier bundles of fibers much or nearly all of the cutting action would be lost and instead the

1st row (left to right): E. C. Cowles, F. L. Simons; 2nd row: A. G. Dries, H. Knudson, and R. J. Proctor



THE SOUTHERN pulp and paper industry has grown rapidly and continuously. The pulp production chart (opposite) shows the trend of growth of each region from 1920 through 1949. Latest data from the United States Pulp Producers Association give the status by percentage of the various regions—the SOUTH leads in 1950 with 55% of the pulp production of the Nation's 5th largest industry.

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Machines and Productivity
The Champion Coating Process
Chemical Cleaning of Filter Beds
Calcasieu Paper Company Story
Filtration and Papermaking
Alkaline Pulping Progress Report
Dissolving Wood Pulp

NEW MILLS are under construction in the South; other mills are adding machinery and equipment to expand their production at the present time. Other projects are close to the announcement stage.

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A TAPPI SUSTAINING MEMBER

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Executive Committee of the New England Section: 1st row: R. J. Proctor; 2nd row: F. S. Klein, F. L. Simons, H. Brown; 3rd row: A. G. Dries, H. Knudson, E. Cowles, Miss Helen Kiely; 4th row: W. Hunter, J. Bainbridge, C. Backus, and Miss Ann M. Brown

fibers would be beaten and the side walls would also be scraped as they were drawn across the edges. In other words, the action would be something like that of a pair of shears which are not set up very tight or when an effort is made to cut a material which is too heavy for the shears to handle.

"The first experimental Knifemill had for a moving element a member which somewhat resembled a circular saw. The teeth provided the advancing edges and these advancing edges were sloped back slightly from the radial direction. The outer or noncontacting side of each of the teeth was ground off to provide a fairly sharp edge. The trailing edge of each tooth was ground on the opposite side. This rotating member was then so located that the teeth would rub against a number of stationary members or bars which were located in a radial direction. By grinding the surfaces adjacent to the trailing edges on the side which was in contact with the stationary members, the areas of the teeth in contact with the stationary members were greatly reduced. Grinding the teeth in this manner also gave them a section which was comparable to the wing section of an airplane. This reduced the resistance of the teeth to movement through the stock and also caused the teeth to set up a pumping action such as that of a very low-pitched propeller blade. This machine was tried out in the laboratory and found to have a definite cutting and hydrating action on paper fibers. To change the emphasis from cutting to hydrating, the pressure between the moving and stationary parts was changed. With this machine it was found necessary to apply a considerable amount of pressure to get the desired result. We were then confronted with the problem of providing adequate mechanical strength and wear resistance. In the course of time a series of commercial-sized machines were built in an effort to work out the correct design of such a machine. By correct design I mean a machine that would be efficient as to power consumption and one which would stand up mechanically.

"The first Knifemill of the present type was built about a year and a half ago. This Knifemill was very similar to the perfected machine which is now undergoing its final tests both in the field and in the laboratory before being offered for sale to the industry."

Empire State

Metropolitan Group

About seventy members of the Metropolitan TAPPI Group attended the first meeting of the season at 6:30 p.m., on September 12, at Fraunces Tavern, at Broad and Pearl Streets, New York City.

The meeting featured a panel discussion entitled: "New Papers from the Use of Chemicals." The meeting was called to order by Vice-chairman Henry Mohrer, in the absence of Chairman John Calkin, who was unable to be present. After the preliminary business was completed, Mr. Mohrer turned the meeting over to Ralph Kumler who acted as moderator for the panel consisting of T. S. Morse, Hercules Powder Co.; Robert Walsh, du Pont de Nemours Co.; Elmer K. Stilbert, Dow Chemical Co.; and Chester G. Landes, American Cyanamid Co.

The following subjects were covered in this discussion: (1) Beater Addition of Resins and Dispersions in Paper Manufacture; (2) Bonding and Wet Strength Resins; (3) Latices for Impregnating and Coating of Paper; (4) Cellulose Derivatives for Manufacturing and Converting Paper; (5) Paper Softeners; (6) Fluidifiers of Starch and Casein Solutions.

Mr. Morse spoke first and told about the development of cationic urea formaldehyde resins for beater use. Comparing them with the original anionic resins which were suitable only for surface addition or impregnation. Of course, the melamine resins were naturally cationic and thus suitable for beater use when first introduced. An advantage claimed for the new urea resins is that they are slower curing, which allows time for the broke to be reused before the full amount of wet strength is developed.

Mr. Walsh described the use of various types of latices such as neoprene, Hycar, GRS, Geon, natural rubber, etc. The properties of many types of paper may be improved by the addition of 1 to 5% latex to the beater. Folding, tensile and tearing strength as well as flexibility may be improved by the use of these elastomer latices. When these materials are used in high percentages (up to 50%), it is better to use saturation rather than beater addition. Papers as tough and flexible as leather, very suitable for artificial leather base stocks, may be made by this method. These latices may also be used in coatings to improve the strength and flexibility of the coating, increase gloss and smoothness and generally improve printing quality. Latices are important as adhesives and laminants. One example is the use of a latex laminant to replace asphalt in furniture wrapping paper, etc. This has eliminated the marking by asphalt which formerly occurred.

Mr. Stilbert described a few of the new products developed by Dow Chemical Co., some quite recently and others over the past few years. For a good many years, methylcellulose has been used for surface application to paper for improvement of surface and printability and for greaseproofing. Beater addition has been tried many times but was found impractical due to poor retention.

A new product CAM, which is a product containing 30% methylcellulose together with some inert salts and moisture, has proved very suitable for use in the beater. It may be added to the system at the beginning of the beating cycle, and is readily precipitated on the fibers with alum. Another derivative of methylcellulose called methocel HG is very good for size press or calender application. It is compatible, with starch solutions and thus allows the use of mixtures of the two materials. Its gell point is 20–25°F. higher than regular methylcellulose.

Densometer readings may be increased two to four times by the use of surface coatings of methocel HG. This material enhances the hydrophyllic character of the paper and increases absorbency. If it is desired to make the paper water resistant it is necessary to cross link the HG by means of Glyoxal, urea-formaldehyde or melamine formaldehyde.

Much progress has been made toward the development of a process for the hot melt application of Saran resins to paper. Stable emulsions of Saran resins, suitable for calender or size press application will soon be ready for commercial use.

Another product recently developed, dehydroacetic acid, is an excellent nontoxic fungicide suitable for use in food container paper and board. This product is designated DHA and a similar derivative is called DHAX.

A familiar product, orthophenylphenol, which is very useful as a fungicide and bactericide, has been handicapped by a strong odor and taste. This product is now produced without odor or taste.

C. G. Landes showed how some familiar products may be

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applied to paper to obtain certain results. An example of this was the softening of paper towels by the addition of emulsified mineral oil, precipitated on the fibers by alum. Mr. Landes gave a demonstration of the Bardac process showing how high percentages of synthetic resin or elastomer emulsions may be precipitated on paper stock. Mr. Landes also showed small plastic trays which had been formed from paper impregnated with resins by the Bardac process.

The difference between a cation active emulsion and a nonionic or anionic emulsion in paper stock was also demonstrated.

The next meeting of the Metropolitan group will be held on October 9 at Fraunces Tavern. This meeting will be on Monday, although they are normally on Tuesday.

This meeting will be featured by an *off-the-record* panel discussion on the subject "Economic and Political Problems of the Pulp and Paper Industry." This panel will be composed of Henry Perry, moderator; George Brooks, representing labor; Roy Neubrech, representing government; and either E. W. Tinker or Glenn Amos of the APPA, to represent business.

October 9 Meeting—Metropolitan Group

The Metropolitan Group of the Empire State Section met at Fraunces Tavern on Oct. 9, 1950 with L. S. Reid the chairman presiding and with about 60 members and guests in attendance.

The program consisted of a panel discussion: "Economic and Political Problems of the Paper Industry" with Henry J. Perry, Editor, Paper Trade Journal, as the moderator. The speakers were E. W. Tinker, Executive Secretary of the American Paper and Pulp Association, George W. Brooks, Director, Department of Research and Education, International Brotherhood of Pulp, Sulphite, and Paper Mill Workers, American Federation of Labor, and Julius Kahn, attorney, and Chairman of the Metropolitan Chapter of the American Society of Foresters.

The problems confronting the industry were thus presented from both the viewpoints of management and labor, while Mr. Kahn, who is an authority on the Constitution of New York State and widely versed in legislative matters, discussed the situation as it exists more locally. Leroy Neubrech, Administrator of the Pulp, Paper and Paperboard Section of the N.P.A., who was originally slated to present the picture from the viewpoint of the Federal Government, was unable to attend.

All the remarks were "off-the-record" and were exceedingly frank. The panel talks which comprised the first hour of the program resulted in a lively question and answer period which lasted over an hour, confirming the interest in the subjects under discussion.

William R. Willets

Lake States

The Lake States Section met at the American Legion Club House, Appleton, Wis., on October 10. The subject discussed was "Recent Developments in Pulp Bleaching."

H. C. Crandall, Chairman of the Section, welcomed the 120 members attending and reminded them that this was the 20th anniversary of the founding of the Section, which occurred on Oct. 17, 1930. The officers at that time were: G. K. Hill—Chairman, Otto Kress—Vice Chairman, and G. F. Hrubecky—Secretary.

Before introducing the panel of speakers for the evening, he outlined the general plan of meetings approved by the officers and executive committee for the year. It had been decided to have two afternoon and evening meetings this year, one to be held at Green Bay on November 14, the second possibly at Stevens Point in the spring. The meeting at Green Bay on November 14 would include a plant visit and a panel of speakers on Semi-Chemical and High Yield Pulping.

Left to right: Mace Harris, T. A. Pascoe, Alan P. Adrian, H. C. Crandall, R. M. Kingsbury, Herb W. Rowe; standing: H. P. Dixson and L. E. Simerl

There would also be an evening speaker on a topic of general interest.

In addition to these meetings, regular dinner meetings will be held in Appleton on the second Tuesday in October, January, and March. No meetings are planned for December or February because attendance at these meetings has been adversely affected by bad weather conditions. It is hoped that this type of schedule will be of more value to the members.

The panel of speakers for the evening were: T. A. Pascoe of Nekoosa Edwards Paper Co., Port Edwards, Wis., who discussed kraft bleaching, R. M. Kingsbury of Forest Products Laboratory, Madison, Wis., who reviewed the problems and theory of bleaching processes for groundwood and semichemical pulps, and Mace Harris of Northwest Paper Co., Cloquet, Minn., who discussed process equipment and instrumentation in the bleach plant.

Dr. Pascoe opened his discussion with the thought that bleaching, especially in the wood pulp industry, is a continuation of the cooking process and that the ideal situation would be a specific reactant to leave the cellulose intact 100%. This of course cannot be and combined reactants must be used, each of which are specific to respective components of the pulp. This procedure has evolved to the multistage bleaching process with its attendant advantage of technical and quality control and low chemical cost as well as the disadvantage of high capital cost.

The things we are after generally in bleaching, according to Dr. Pascoe, are: high brightness, e.g., 80% or better; retention of strength, particularly in kraft; color stability; tendency toward blue color rather than the yellow; well balanced pulp, i.e., proper relation of the physical tests; cleanliness and freedom from metal contamination. A 5 or 6 stage bleach can produce a pulp of up to 80% brightness without degrading. We should, however, satisfy the chlorine demand in chlorination so that no more than 2% is required as hypochlorite.

Some of the more specific bleaching agents are sodium chlorite, sodium peroxide, hydrogen peroxide, sodium peracetate, chlorine dioxide. The peracetate is a gentle selective bleaching agent giving a blue white color. The advantage of chlorine dioxide is that it is selective, has a high oxidation potential, operates under wide ranges of pH and temperature conditions, and can be forced by drastic conditions without damage to the pulp.

A look into the future tells us that pulps up to 85–86% brightness can be made in our present equipment at small cost if we use $NaClO_3$ to generate ClO_2. Perhaps pulps to 90% brightness can be obtained if we use ClO_2 under acid conditions, probably at high temperature and high density. There will of course then be tough problems of equipment to solve.

Mr. Kingsbury outlined some of the history of high-yield bleaching. He stated that the investigation of groundwood bleaching began 40 years ago, but that the first real progress

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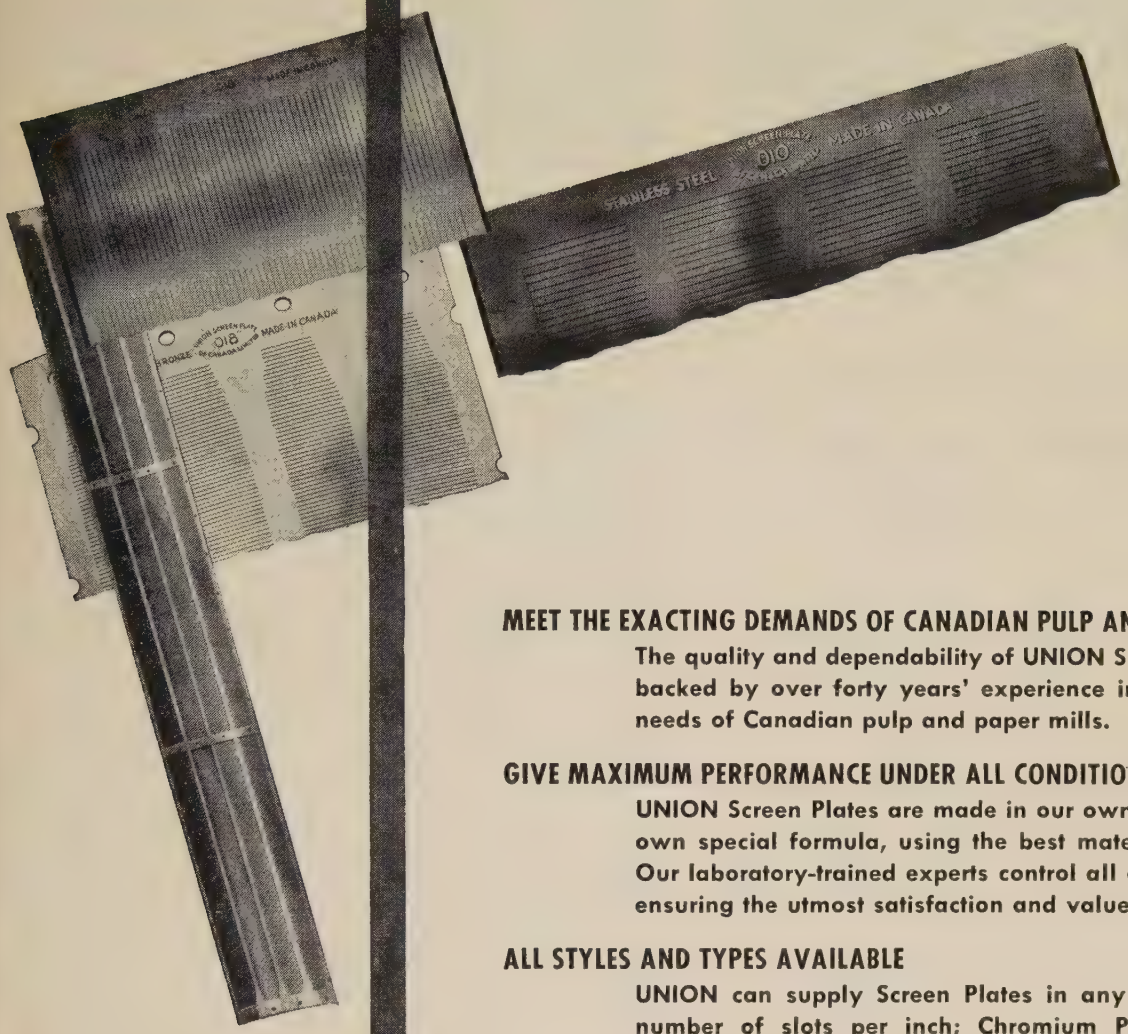

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was made in 1930. Since then peroxide, hydrosulphite, and hypochlorite processes have been developed. The first mill scale trial with peroxide was made in 1941 at the Norfolk mill of St. Regis.

It was thought originally that the bleaching was due to nascent oxygen. However, it is now felt that the HO_2 anion is the active bleaching agent. Metals, such as iron and copper can be detrimental to the bleaching action, also bacteria producing enzymes are harmful. Pulp pretreatments are proposed as being helpful, perhaps in removing metal contaminants.

In 1932 the hydrosulphite process was proposed to bleach fresh pulps or pulps stained with iron or sulphur compounds. Sodium or zinc salts applied as near as possible to the paper machine were recommended. Recently zinc hydrosulphite has been used shortly after the deckers or grinders. The chief problem in hydrosulphite bleaching is corrosion; high chrome steel or molybdenum steel is best to combat this.

In connection with semichemical bleaching, Mr. Kingsbury mentioned, among other things, that the milling of the softened chips is very important to successful bleaching, and a very successful means of mechanical treatment is curlating.

One of the great problems is the difficulty involved in washing semichemical pulps in commercial equipment. The solution may be to blend this pulp with chemical pulps. Another interesting thought is that with the expansion of production of the semichemical pulps, different methods are used for different end use, e.g., in glassine it is desired to leave as much hemicellulose as possible so as to aid hydration. Mr. Kingsbury further elaborated on the interesting possibilities of specific pulps for specific end use.

Mace Harris stated that the fiber used determines the type of bleach plant. He suggested that the first step in building a bleach plant is to visit all known plants, ask help from all bleach producers and equipment manufacturers, and work in one's own laboratory as much as possible with the conditions peculiar to your own mill.

Some of the fundamental principles in bleach plant operation are: well-washed unbleached pulp blended with other cooks for the sake of uniformity; good control of consistency—should use hot water to heat pulp, not steam; use of liquid level control; accurate metering of stock. If the blended stock is metered and if the chlorine demand is known, then bleaching chemicals can be added accurately. It would be well also to allow a five-minute retention of chlorine with the stock and so set this up that the operator can observe the color change in order to determine the correct amount of chlorine added. Experience in this regard will be of value in ultimate control of bleaching. Of course good pH control is essential.

A good practical principle in bleach plant operation is to use a short line to convey the chlorine to the stock and use an automatic cut-off valve in case of power failure. Something new in chlorine valves is a diaphragm instead of a packed valve. However if a packing is used, Teflon may be recommended.

A good rule to follow is to have the instruments in a room separate from the bleach plant.

In conclusion, Mr. Harris said that in building a bleach plant, build big enough and leave room for expansion.

A question and answer period followed the presentation of talks by the panel speakers.

Ohio

The Ohio TAPPI men met on October 10 at the Manchester Hotel in Middletown, Ohio, jointly with the Miami Valley Division of the Superintendents Association. The meeting was one of the best attended on record with 193 persons present.

The group was welcomed by John Burdsall, representing the

Superintendents Association. Don Goodman, Chairman of the Ohio Section of TAPPI replied to Mr. Burdsall's welcome by stressing the importance of the cooperation of the TAPPI and Superintendents organizations.

E. A. Lindsay

The program for the evening was arranged by the Superintendents Association through the courtesy of George Kjehnle, Jr., Manager of the Northern Division of the Cincinnati Gas and Electric Co., and C. W. McFee, Sales Promotion Manager of the Lamp Division of the General Electric Co.

Mr. McFee introduced the principal speaker, E. A. Lindsay of the General Electric Co. who presented a very interesting talk entitled "Light and Paper." Mr. Lindsay's talk was illustrated throughout by visual demonstrations and slides. His talk follows:

Light and Paper

Good lighting is an important factor in all phases of paper production and use. The essential component in most papers is wood pulp. Light plays the role of supplying the energy for photosynthesis, the complex, integrated process of converting light to growth. Efficient handling of this timber and the various phases of converting it into finished paper require proper lighting for efficient operation. Adequate lighting satisfactorily integrated into the technical processes for converting the finished paper into newspapers, magazines, boxes, and many other products can make a big difference. Even here, this part of the lighting story is not completed. In the actual use of the paper product, particularly in the cases of printed material, the reader depends on good lighting for visual satisfaction.

This paper will discuss the requisites of good lighting in the papermaking industries.

Many of the advantages of good lighting are tangible and definite. They can be readily demonstrated by laboratory or field tests. In this category are such things as fewer mistakes, less fatigue, and additional production with the same or even less effort.

Many benefits of good lighting are intangible, difficult to determine by actual tests, and, at least equally important. These benefits which must vary from plant to plant, are in most cases probably more important in a given plant than those which can be measured directly. Their influence upon such factors as employee relations is constantly in the direction of more profitable operation. These are "extras" that can be expected when well-planned lighting is coordinated with other advanced management policies.

Productivity increases as illumination increases—rapidly at lower levels and at a reduced rate for very high levels. The expenditure of human energy decreases with increased levels of illumination. It continues to diminish long after the output curve becomes essentially flat. This indicates that for most tasks a lighting level is reached where there will be very little additional increase in output. This often indicates a limit of manual dexterity, rate of understanding, etc., rather than lack of improvement in seeing. It is still desirable to improve the seeing condition beyond this point. If the worker can perform his task with less effort, he can carry out his duties with greater safety and accuracy and with less strain, nervousness and fatigue.

Basic Considerations

The specifications of lighting for any manufacturing process should be related to requirements suited in general to its nature and with special reference to characteristic seeing tasks. If seeing tasks are difficult or prolonged, then not only high levels of illumination are required, but specially adapted supplementary lighting may be necessary to make the seeing easy. Basic factors involved are the size of detail to be observed, its color and contrast with its background (does it stand out, or does it blend so that it is hard to see), the length of the individual seeing operation, extent to which the task is repetitive (is it intermittent or continual), (is it moving), and whether color discrimination is involved. Thus, the lighting of papermaking processes may fall into two general classifications: (1) those in which the visual tasks are not unduly severe (which may be adequately served by

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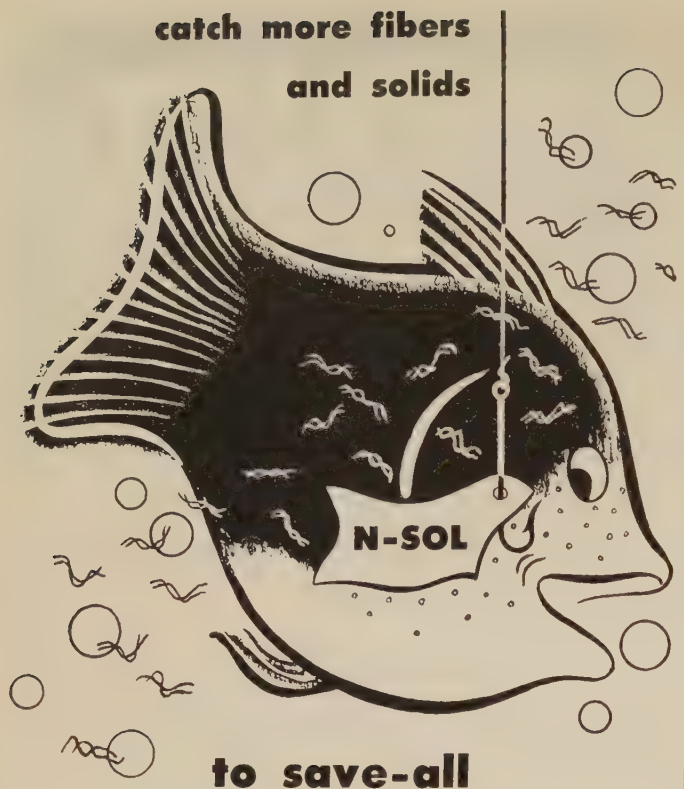

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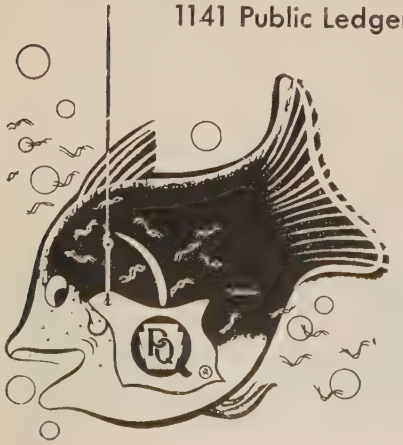

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a good system of general illumination) and (2) those requiring special treatment.

Manufacturing Areas

For the general manufacturing processes the lighting system should not only give a good distribution of light over the area, but shadows should not be pronounced. These requirements are, in most cases, best met today by lighting systems employing flourescent lamps where the mounting heights do not exceed approximately 25 feet. They combine high efficiency with low brightness (for eye comfort) and good color rendition. The lighting recommendations usually warranted for areas of this type are in the 40 to 50 footcandle range and usually utilize two-lamp fluorescent equipment. The standard cool white lamps are usually used except in the critical color discrimination area. The lighting problem in these areas is discussed under the heading "Color Matching."

In relatively high bays (above approximately 25 feet) filament or mercury lamps, or combination of filament and mercury, are often best adapted. They are preferred over fluorescent because of reduced maintenance costs even though the system is somewhat less efficient. The illumination level should usually be in the 40 to 50 footcandle range.

One of the aspects which may influence the choice of a particular light source for a general lighting system is reflected glare. For example the use of high brightness sources such as mercury or filament lamps in the calendering areas is usually undesirable due to the high brightness specular reflections from the polished surfaces of the rolls.

Typical of other lighting requirements in paper manufacturing plants are the chipper and barker areas where filament and/or mercury systems are particularly suitable. As much of the work in these areas is performed by nearly automatic machines, the seeing tasks are often intermittent and a lighting level of approximately 30 footcandles is in order.

Light Conditioning of Manufacturing Areas

Lighting of industrial areas has until recently too often been handled as a problem in obtaining a certain footcandle level with often little consideration of visual comfort. Present trends indicate a much more acute realization of the importance of the real advantage of providing pleasant visual environments. Improvements in comfort are achieved by better lamp shielding, higher room reflectances, and better control of room brightnesses. These features are obtained by the use of center or longitudinal shields, or egg-crate louvers to provide better lamp shielding, the use of proper paint reflectances, and the proper distribution of light in the room, particularly on the ceiling and upper wall areas, as these tend to be the darkest parts of the environment. The use of light-colored paints on the walls and machines is growing as a means of not only providing bright surroundings, but a cheerful environment. Of the many color combinations that may be employed, the psychologically cool blue green is particularly adapted to warm areas, while buff or light brown tend to give warmth to the surroundings. Machines are similarly painted to provide low brightness contrast with the work. In some cases a contrasting color is used to call attention to controls and working parts.

Papermaking Machines

The heart of any paper manufacturing plant is the papermaking machine. Here the pulp is formed into a blanket, the water removed and the paper formed in a continuous sheet. The quality of the paper is primarily determined at this stage of manufacture. It is, therefore, particularly important that the papermaking machines be properly lighted. On some parts of the machines it is difficult to supply adequate illumination because of the severe operating conditions. There may be a considerable amount of flying water and pulp which constitutes a severe maintenance problem if the lighting equipment is mounted close to the machine. It is usually necessary to mount the equipment in this position because of the mechanics of machine construction, therefore, anything that can be done to provide better illumination and less maintenance difficulty is highly desirable.

The lighting of a typical papermaking machine consists of 100-watt lamps in vapor-proof equipment mounted on 5-foot centers to supply adequate illumination on this portion of the machine. For the more difficult seeing taks on the lower parts of the machine, angle floodlights are mounted along the building wall: 750-watt incandescent lamps are used in these reflectors which are spaced on 9-foot centers. The general lighting in the room is supplied by semicontinuous rows of two-lamp 40-watt fluorescent equipment (fixtures on 8-foot centers in rows). The fixtures in the aisle between the two machines are mounted at an angle in order to provide better vertical illumination on the sides of the machines. At the discharge end of the machine supplemental fluorescent units are employed over this more critical seeing area.

In case of a break in the paper sheet, it is necessary to rethread the machine. Immediately following the break and during the

rethreading operation there is a considerable amount of spoiled paper. This is usually thrown through holes in the floor to the area below where it can be salvaged for reprocessing. In order to handle this spoiled paper efficiently, reasonably good lighting should be available in this salvage area. The lighting supplied by two-lamp 40-watt fluorescent units mounted on 10-foot centers with one row on each side of the papermaking machine mounted on the floor above would be sufficient. The lighting level of approximately 10 footcandles is adequate for the efficient handling of this bulky paper.

Calendering

The general lighting in the calendering area should provide adequate illumination for the safe and efficient handling of the heavy paper rolls and for the adjustment and service of the calendering machines. Lighting levels in the 50-footcandle range are desirable for efficient operation. The fluorescent type of equipment is most suitable because of the relatively low brightness reflections from the polished rolls and the machine surfaces. The wide distribution of most industrial fluorescent fixtures provides good vertical illumination on the calender.

Bugs

In many plants, particularly during the summer months, the problem of eliminating spots on the finished paper produced by insects being trapped in the manufacturing operation, particularly at the calenders, is a difficult one. Some plants have installed yellow lamps in an effort to eliminate this insect problem because most nocturnal insects are sensitive only to blue light. The use of yellow lamps which produce no blue light does tend to minimize the problem. However, the only complete solution to the insect problem is to make the building completely insectproof by means of fine mesh screens or complete air conditioning.

Beaters and Refiners

The seeing requirements in the refiners and beater areas are usually rather casual. Lighting levels of approximately 30 footcandles are desirable for the inspection and adjustment of the machines. Filament lamps are usually used because of the simplified maintenance as compared to fluorescent installation. One new development in light source, the R-52 self-contained reflector lamp in 500-and 750-watts, is well suited to applications of this type. This lamp will be discussed at greater length under the heading of maintenance.

Chippers and Barkers

Good lighting in this type area is needed because of the hazards involved in handling the bulky material and operating the heavy machinery used in these operations. Lighting levels in the 30 to 50 footcandle range are desirable. The 750-watt R-52 reflector lamp is particularly suitable due to the rapid rate of dirt accumulation in these areas.

Digester Rooms

Modern digester rooms are very similar to control rooms in power plants, etc., and require careful consideration of the lighting installation in order that adequate illumination be provided on the scales, dials, and controls. Considerable care should be exercised in order to prevent excessive reflections in the glass-meter faces. Another important consideration in this type of area is the proper brightness control of the entire seeing environment. This usually is accomplished by the use of light colors of paint throughout the areas. The primary objects of attention are the meter scales, and proper lighting is accomplished by having everything else approximately the same brightness.

Color Matching

The most accurate representation of color is provided by a light source which does not emphasize or subdue any portion of the spectrum. In other words, a source which has equal amounts of radiation in all colors or portions of the spectrum would be preferred. The recently announced de luxe cool white lamps approach this optimum much closer than other light sources and are, therefore, the best lamps available today for viewing of colored materials. The new de luxe cool white fluorescent lamp is also well adapted to operations where color discrimination, rather than accurate matching is desired. If, however, it is necessary to match two samples it is then desirable to deliberately distort the appearance of the two samples first by lighting them with a source predominantly blue in spectral composition and then lighting them with a source predominantly blue in spectral composition and then lighting them with a source which is predominantly red in spectral composition. If a color match is obtained under these two sources then the samples will match under any other lighting condition. There are a few materials which fluoresce or produce visible light when illuminated by ultraviolet radiation. For this

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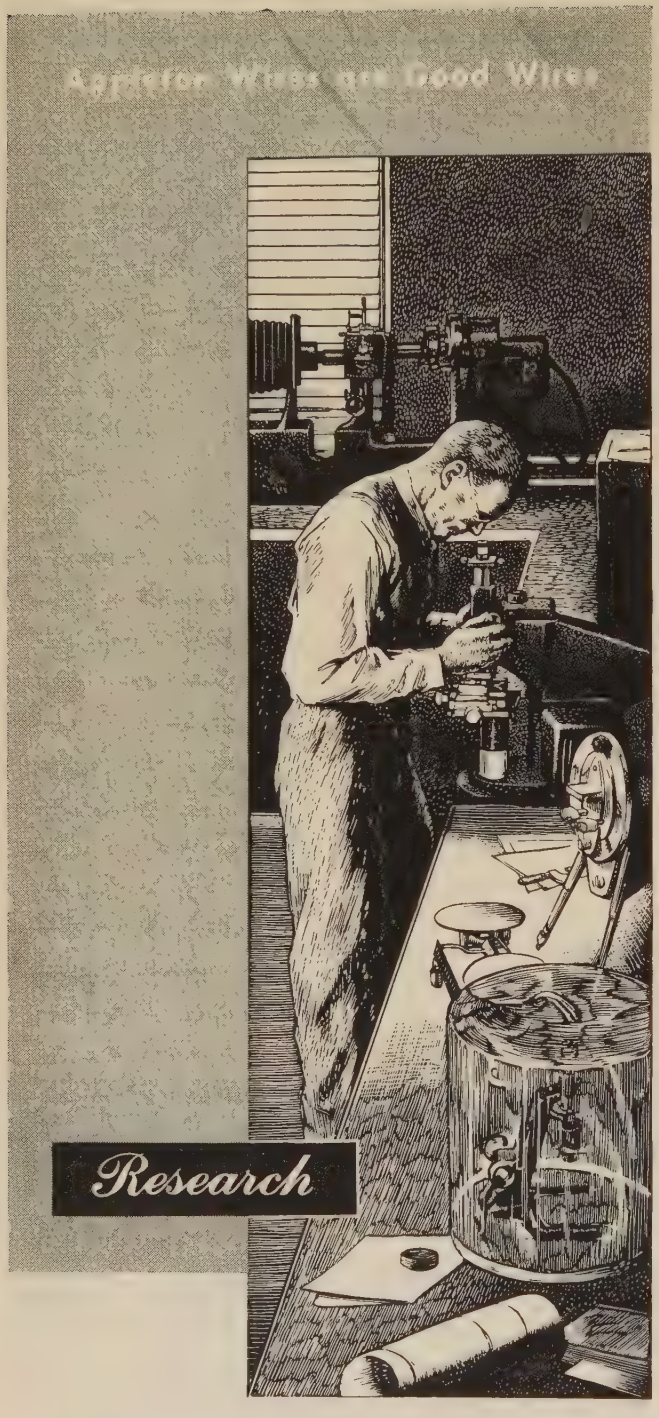

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reason, the source which is predominantly blue should also contain enough ultraviolet radiation so that these fluorescent effects can be produced. The source which is predominantly red should not contain ultraviolet. The daylight fluorescent lamp is a logical choice for the bluish component and the reddish component is supplied advantageously by filament lamps.

Difficult Seeing Tasks

The inspection tasks are most apt to be difficult visually, although there may be difficult seeing tasks at any stage of the manufacturing process. Critical inspection involves in many cases very difficult seeing problems. These problems can be grouped broadly into three main categories.

In many cases it is only necessary to supply enough lighting so that the operator can use his visual ability to best advantage. In seeing the area over the vats in the papermaking machines, it is only necessary to supply adequate illumination.

For other visual tasks a light source having highly directional characteristics is desirable. Where it is necessary to examine the surface of the paper for small imperfections such as wrinkles, tears, spots, etc., the use of highly directional light sources, in this particular case automotive-type fog lamps are recommended, provides modeling or three dimensional effect on the small irregularities in the paper surface. The slight shadows cast by these irregularities make the detection of defects very much easier than with ordinary types of lighting. The fog lamps are particularly suitable for this operation because of the sharp cut off above horizontal. In other words, the operator can work directly facing the units without having high brightnesses directly in his field of view. It is also possible to utilize fluorescent lamps mounted in the same position with a properly designed reflector to give adequate shielding to the operator.

A third type of lighting effect which is sometimes helpful for difficult seeing tasks is the use of a large area relatively uniform brightness source usually consisting of a bank of fluorescent lamps behind a diffusing media such as opal glass or plastic. This type of source is particularly suitable for the critical inspection of polished surfaces. A calender roll, for example, can be inspected critically for smoothness of finish if a uniform brightness light source is reflected in the surface of the roll. A further modification of this technique is the application of some type of definite pattern on this uniform brightness source. The pattern should be clean and sharply defined assuming that the surface is optically smooth. A rough surface causes the distortion of the image.

Laboratories

The desired working environment in a laboratory is usually somewhere between that of a general office and a manufacturing area. Usually there is a considerable amount of desk work, writing of reports, notation of data, etc., as well as critical observation of processing similar to that out in the manufacturing areas, but often on a reduced scale.

The efficient and accurate performance of the laboratory personnel requires illumination levels in the 50 to 100 footcandle range for the general activities throughout the area.

The critical appraisal and inspection of products, particularly the darker shades of paper, often requires additional illumination over the inspection area. This phase of lighting was discussed under a separate category, "Difficult Seeing Tasks."

Shipping and Receiving

In the shipping and receiving areas, the most difficult visual tasks consist of making out forms, checking labels and stock, packing and wrapping, etc. These areas should be lighted in much the same fashion as the general manufacturing areas. A 50-footcandle level supplied by two-lamp fluorescent equipment in continuous rows on 10-foot centers gives uniform lighting. If 40-watt fluorescent units are used, continuous rows on about 10-foot centers will provide 40 to 50 footcandles, and if 85-watt units are used, comparable lighting will result from rows placed on approximately 13-foot centers.

For the more casual tasks of loading, rough crating, etc., lighting levels of 20 to 25 footcandles are more typical. These may be obtained by omitting one half of the reflectors of a continuous row system, and should the area be used later for manufacturing processes, the higher production lighting level is readily obtained by completing the continuous rows through the installation of the remainder of the reflectors and auxiliary equipment.

In many areas of this kind, a service desk is located adjacent to the stock room. If this is the case, it should be well illuminated for the efficient handling of stock and the record work which is necessary. A continuous row of two-lamp fluorescent equipment over the length of the counter is quite adequate for this purpose. The type of lighting equipment which is utilized usually is coordinated with that used in the adjacent area, whatever type of source used there usually being continued through the stairways and corridors.

Stock and Tool Rooms

In all manufacturing plants it is necessary to devote a considerable amount of space to the storage and handling of tools and small parts. This is usually done in stock bins placed in rows on either side of relatively narrow aisles. The aisles are usually about 3 feet wide and the bins are approximately 7 feet in height. The lighting requirements in an area of this kind are primarily supplying illumination on the vertical surfaces of the boxes and cartons stored in the bins, or in the case of loose or bulk materials, the adequate illumination of the interior of the bin. In all cases the primary requirement is to supply vertical illumination. One of the better methods of lighting this type of an area is by utilizing continuous rows of single lamp fluorescent equipment down each aisle. Lighting units should be mounted in the center of the aisle approximately at the top of the upper bins so that they provide adequate light sideways toward the bins. It is highly desirable that these units be mounted no higher in order that the light reaches the inside of the bins efficiently. It is also very helpful to finish the inside of the bins in white or other light color to reflect the light to parts not lighted directly by the lamps. In some types of bins, small aprons project into the aisle at the lower front of each bin. If this is the case, these aprons should be finished in a high reflective paint in order to redirect some light into the interior of the bin.

Warehousing

There are in general two types of warehousing operation. Active warehousing consists largely of temporary storage of material used in current production or prior to shipping. This type of warehousing justifies lighting levels of 15 to 20 footcandles in order to facilitate the handling of material and minimize the hazards of trucking traffic. One good lighting solution is continuous rows of two-lamp 40-watt or two-lamp 96T12 fluorescent units on approximately 20-foot centers. If the ceiling height is less than approximately 20 feet, the rows should be placed closer together. One typical arrangement is continuous rows on 10-foot centers omitting half of the units in each row. If at some later date this area is to be used for a manufacturing operation, it is relatively easy then to complete the rows and provide a lighting level commensurate with the more difficult seeing tasks in the manufacturing process.

The other type of warehousing consists of storing materials that are needed only occasionally. These materials may consist of spare parts, special low-demand paper types, etc. The lighting in this type of areas is usually at a considerably lower level then necessary for active warehousing. In most cases, the lighting is supplied from filament lamps and the lighting level is of the order of 10 footcandles.

Office Areas

The seeing tasks in the office areas are generally prolonged. They are often more difficult than necessary because of poor quality of the tasks themselves, low levels of illumination, and seeing—working environments which hinder rather than contribute to effective employee performance. The lighting should provide a pleasing, comfortable visual environment for the employees. People do better work in this kind of surrounding. It has been confirmed many times by experience and actual tests. One of the more recent tests was conducted by the Bureau of Internal Revenue. In the particular area studied, the employees transfer information from income tax returns to key punch cards. When the lighting was changed from 10 to 50 footcandles and light wall and furniture finishes in pleasant colors were provided, the rate of processing cards increased by 5.5%. This was in spite of the fact that the complexity of several forms was increased by as much as 50%. The annual value of this 5.5% increase in performance is twice the cost of renovation. In other words, during the first six months, the increased volume of work produced by the employees had completely paid for the new lighting and redecorating.

The trend in lighting is continually toward improved seeing conditions. As new developments in light sources and lighting equipment improve lighting and decrease its cost, more light is demanded. As costs of office operation increase, the most efficient utilization of employee capabilities is more and more imperative. Lighting is a potent factor in this improvement. There are, of course, some office areas, such as lobbies and reception centers, where the seeing tasks are relatively casual and lighting levels of the order of 10 to 20 footcandles are often adequate. On the other hand, there are other office tasks considerably more severe than the average, such as bookkeeping, detail drafting, etc., where higher levels of lighting are appropriate. For tasks of this kind, lighting levels of 50 to 100 footcandles are more desirable.

Visual Environment

It has been indicated previously that good lighting requires a pleasant visual environment.

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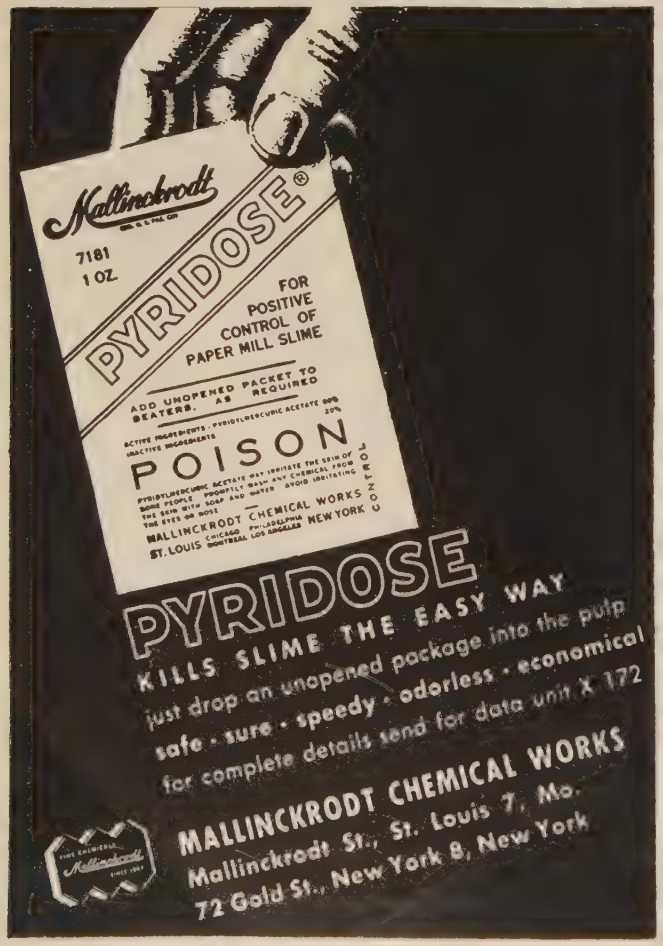
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This means that all brightnesses in the area should be of the same order of magnitude. Strong differences in brightness create disturbing reactions. High brightnesses, such as are created by bare lamps, and high brightness window or glass block areas, cause severe glare conditions which interfere with seeing and induce eye strain and fatigue. Shiny surfaces such as polished or glass desk tops reflect these high brightnesses into the workers' eyes causing reflected glare. It is particularly important that these glare conditions be reduced to a minimum. In order to create a pleasant visual environment it is very important that all surfaces in the room are finished in light colors. The finishes should be nonglossy for comfort and best appearance. If reflections are present, they are distracting and often mask the color and pattern of the surfaces.

There are very few exceptions to the rule that ceilings should be painted white. Without exception they should be of very high reflectance to keep lighting efficiency high and to give a luminous background against which fixtures are seen. The outside surfaces of fixtures should also be of high reflectance, but not uncomfortably bright, for the same reason—to minimize the brightness difference between the inside and outside of the units.

The side walls from either the ceiling or the fixture line down should be finished in a color which will reflect 50 to 60% of the light that strikes the surface. The floor areas should reflect at least 20%, while furniture and equipment finishes should be of the order of 30 to 35%. The desk tops and other work surfaces are especially important and should reflect 30 to 35% of the light that strikes them. By utilizing materials of this reflectance a comfortable over-all brightness condition is created which makes a comfortable, efficient, and pleasant work space.

Some care should be exercised in choosing particular colors so they harmonize with each other, but many different shades can be used as long as they are handled in a harmonious manner.

Maintenance

One of the most important problems in lighting of paper plants is the severe rate of depreciation due to dust and dirt accumulation on lighting equipment, and other room surfaces. It is particularly important to keep in mind that a lighting system is installed for one purpose only, namely, to supply the necessary amount of light, at the minimum cost, and in a manner to help create a comfortable visual environment. In many plants throughout the country under existing maintenance practices (no regular cleaning), the lighting system is delivering only 40% or less of the light that it is capable of producing. By a very small investment in a cleaning and lamp replacement plan, often less than 20% of the operating cost of the lighting system, it is quite possible to realize twice as much light as the system is presently producing. Under these conditions, this means that the present unit cost of light (the cost per footcandle actually delivered on the work) has been reduced by nearly one half when reasonable maintenance is carried out.

No lighting system remains effective for any considerable length of time unless a definitely planned and well executed maintenance program is carried out.

Safety

The problems of safety in any manufacturing process are always of prime concern. Good lighting reduces the hazards in any process by insuring that the worker can see and avoid them. Accidents in the erection shops of the Allis-Chalmers Milwaukee plant were reduced by 43% by an improvement in the workers' seeing environment. Admittedly, such spectacular results cannot always be expected, but this chart does indicate the close interrelation between good lighting and good safety records.

Summary

Good plant lighting can no longer be considered as a luxury nor as just a necessary overhead item. It can and should be considered as an investment in efficient and economical operation. Modern successful concerns insist on the best in tools, business machines, and labor. It is equally important that they insist on the best in lighting installations; lighting designed to be adequate in quantity, of such a quality that it will be comfortable for the workers' eyes and will do its part in creating a pleasant, efficient working environment. It is our hope that the examples and discussion here presented will be of help to the paper industries in making good lighting—a productive tool in your progressive manufacturing operations.

Question: What percentage of energy can be consumed by a person in just "seeing?"

Mr. Lindsay: This can amount to 50% in poorly lighted areas.

Question: How are lights kept clean?

Mr. Lindsay: The best way to keep lamps clean is by observing a definite cleaning schedule, perhaps 2 to 3 times a year. This becomes practicable when one realizes that over 50% of the light can be wasted by dirty lamps.

The use of the proper type of lamp and proper scheduling of lamp replacement and cleaning can minimize the cost of lamp maintenance. This is emphasized when it is realized that it costs about 50 cents to change a single light bulb in a factory.

Question: What is the best means of facilitating color matching?

Mr. Lindsay: Deluxe cool white is best to use because it does not emphasize any particular color. Critical matching requires the use of both the blue distortion and red distortion. There are lamp units made to accomplish either blue or red distortion by the flick of a switch.

Question: In the paper mill should blue or white light be employed?

Mr. Lindsay: It makes little difference whether blue or white light is employed. Insects see only the bluish range of color. Thus if very little blue light is used, insects will not be attracted.

Question: How much light should be provided in a color matching booth?

Mr. Lindsay: 200-foot candles should be enough.

Question: Has the danger of wound poisoning resulting from cuts by broken lamps been eliminated?

Mr. Lindsay: This danger has been overrated as only a few types could give this trouble. Burned-out lamps should be treated with caution as a matter of course. The use of beryllium has been discontinued in lamps that had given poisoning problems.

The November meeting of Ohio TAPPI will be held at the Manchester Hotel on November 9. This meeting will celebrate 15 years of growth in the Ohio Section. An interesting program will be presented.

Delaware Valley

The first meeting of the Delaware Valley Section was held Sept. 28, 1950, at the Engineers' Club, Philadelphia

In the afternoon, preceding the meeting, members and friends of the section made a very interesting and enjoyable tour through the modern gravure printing plant of the Triangle Publications, Inc., in Philadelphia. The visitors were given a history of gravure printing and were shown the paper storage and handling, machine and carpenter shops, ink mixing, press room, gravure processing, photographic department, etching department, the bindery, control laboratory, solvent recovery, and automatic baling equipment.

August Erspamer, Chairman, called the evening meeting to order and called upon Frank Lovegren, Treasurer, to read the treasurer's report.

Arthur J. Haug, Chairman of the Program Committee, called attention to the next meeting to be held at the Engineers' Club, Philadelphia, on Oct. 26, 1950, at which the "Principles of the Curlator" will be discussed.

Mr. Haug introduced the speaker of the evening, Harrison F. Dunning, Manager of Paper Mills, Scott Paper Co., Chester, Pa. After the discussion which followed Mr. Dunning's talk, "Human Relations in Industry," appreciation on behalf of the section to Mr. Dunning and to the Triangle Publications, Inc., was expressed by Mr. Haug and the meeting was adjourned.

Human Relations in Industry

I've been kicking around in the paper industry for some 15 years now; and, while I've heard and read lots about TAPPI, this, oddly enough, is my first real exposure to it. I think one day, some years ago, Paul Baldwin got me to sit in on a couple meetings at the annual paper week in New York—but I just couldn't keep up with the resins, the formaldehydes, and the pH's in the front rooms; or the bottles and the promotions and the reorganizations in the back rooms. I wasn't technically trained for either of these activities so since that time I've concentrated my meeting efforts on those dealing with people and policies and production techniques. And that apparently is what you want me to treat with here tonight.

I don't know why me—and I don't know why this topic "Human Relations in Industry"—but I'm delighted you have asked for it, because it shows a recognition on your part of the new importance of this human relations matter in any and every activity or enterprise. In other words, you are smarter than I am, for I don't expose myself to that vast body of technical knowledge which any man in the paper field should have, but you are exposing yourselves to that new body of knowledge on human relationships which any man in the technical field should have.

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May 26 – June 10, 1951

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You may not like some of the things I say to you tonight because I'm way over on this human relations side in my approach maybe too far over for you. Perhaps I'm not alone on that, however, and as evidence in that direction, I'd like to start by commenting on something Larry Appley, President of the American Management Association, wrote last July in an A.M.A. publication. He said that since it looked like a new war economy was brewing, it might be well to analyze the experience of the last war and settle one question: When you have a real tough job to do, and you can't have the ultimate in a technically trained man, who is also a top administrator, which is it better to have—the technical man or the top administrator? His article went on to conclude that the last war proved that an able administrator was more important to over-all success than an able technical man—and cited numerous instances of proof, such as automobile administrators making good tanks in high volume, food companies making war products, and the like. Why is this?—he asked himself. Because all the technical knowledge is of no avail unless a group of people can be organized to use it effectively, because organization of an effort is No. 1, and getting people to want to make the effort is No. 2 in getting a job done.

Now, these remarks are not meant to deprecate in any way technical training or its vital importance in any production effort, but they are meant to point up rather graphically the necessity for supplementing or complementing technical knowledge and training with an ability to make it effective through people—and that's where human relations come in.

Let's approach it from another angle, leaving technically-trained men out of it. For some years I was in personnel work, and from time to time, men from the mill—foremen, supervisors—would come down to arrange for additional courses. They would suggest taking courses in time study, industrial management, machine shop practice, or something in the line in which they were already specialized and best.

I tried to influence them to take up: industrial psychology—to influence people, English composition—to write to people, or public speaking—to talk to people.

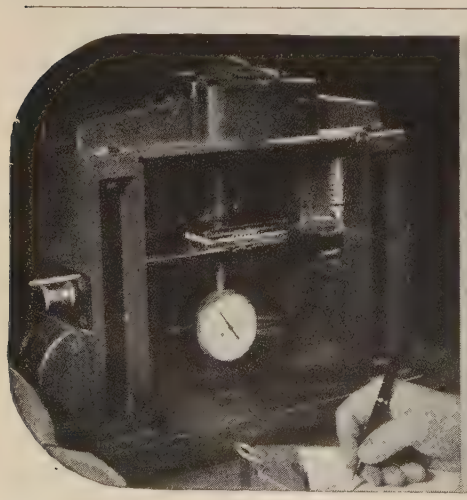
The purpose, of course, was to prevent too complete specialization, to broaden these men through cultural business subjects, if you will, to enable them to use their current knowledge and experience more effectively through people before trying to widen their knowledge and experience. Because a good manager, supervisor, or department head is successful largely on his ability to get other people to do the job rather than his own ability to do the job. And, since he must first be able to understand people, and, second, be able to address them effectively, these three courses, it seemed to me, could be of greatest help in their personal development.

That, in essence, is why the Penn State College Center at Swarthmore is, this year, offering a new course which we on the Center's Advisory Board worked up. It's called manager-power, and it's designed to prevent specialists from becoming more specialized, because we recognize that managers and administrators must be broad people, must know people and organization better than any other single thing. In this Penn State course, we teach just four basic things to achieve that result: human relations plus communications plus economics plus organization. We hope those four things, added to a specialized knowledge as a technical, production or office man, will add up to more manager-power for the industries served by the Swarthmore Center.

Let's approach this thing from yet another direction. Let's take your 5-year old boy. You catch him lighting matches. You scold him and you tell him he should not play with matches again. He asks, "Why not?," and if you answer, "Because Daddy says so, that's why," you can bet that the next time he has a chance and you are not around, he will light a match and find out for himself. But if, when he asks, "Why not?," you light a crumpled newspaper near his face, the shock of instantaneous flame and the heat will describe vividly to him "Why not?."

Well, I maintain it's just the same with the man who works for you or with you. Let's say you determine furnishes in a paper mill. You want to make a change to help operations or quality or costs, or all three. You tell the paper mill superintendent about it. He asks, "Why?." You say, "Because it will help," thinking to yourself that there's no sense explaining it to this dumb jerk because he won't understand it anyway. Well, that's damn poor relations. You not only insult his intelligence, you deflate his ego and people live on ego. You do, I do, all of us do. If we can't feel important, if we don't feel important, we won't pitch as hard for success. And the paper mill superintendent, if the hurt is sharp enough, is liable to show Mr. Brains that he isn't so darn smart after all because he can louse that new furnish up on the machines without half trying, and that's just what he'll do.

In our company we try religiously to tell our people not only what we want them to do, but why we want them to do it, and further, and this is what makes it count, we tell them the reasons behind the why. Even if they don't understand, many times,



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they are flattered that someone took the time and trouble to explain; and if they *do* understand, they feel important to be in on the know and then they want to make the thing they do work right. It's as simple as all that. Sure, it takes patience to do this, it takes tolerance, too, but the rewards are so great that it's worth the price many times over. If you haven't been doing it, try it and see. It won't take long to prove itself to you, I'm sure.

I said we go to some pains in our business to do this. We do it fairly, in individual contacts; we do it in regular meetings. And, every once in a while, we do it on a truly large scale. Let me tell you briefly about one such operation. A year ago we were concerned about quality. We felt that it was timely to revitalize our entire personnel on the importance of quality maintenance. Our business lives and prospers on its quality; it's the very foundation of our consumer franchise. So we felt we ought to do something about it.

We could, of course, do the obvious thing, call in our foremen, supervisors, department heads, and technical men, crack the whip, etc. What would they then do? Neglect everything else, much of which is important, and concentrate for a while on quality. We'd get some gains, many of them temporary in nature, I'm sure. We'd get some thinking, but only by the people who consider quality part of their normal responsibility. We didn't want that, we wanted everybody to be as quality conscious as the quality director. So here's how we went about it.

Under the guidance of our advertising, public relations, and production department, our "Progress Through Quality" campaign was initiated. This campaign took in all of our plants simultaneously and consisted of a very comprehensive program of clever slogans, performance scoreboards, a movie about the plants and the people working in these plants, and a series of informative talks at employee rallies held at all plants. There was a talk, of about 15 minutes in duration, given by a top management official on the history of our company, the part quality has played in our growth and its meaning to all Scott employees. Another talk was given by the mayor or some other official of the town, in which the plant was located, in which the advantages of the plant and its payroll to the town were stressed. A talk was also given by a representative of one of the leading women's magazines, who stressed the meaning of quality from the consumer's standpoint. This campaign was, we think, successful in that it presold most of our 4000 people at least 80% of the way on quality, just as a product advertisement in a magazine presells the customers who come into the stores. This meant our supervisors only had to do the last 20% of the selling of the quality story.

Yes, you have to get your results through people, for only people start, stop, and do things. Not just one or two people, but all the people have to get into the act on an important basis if you want to achieve greater than usual success.

Now, you don't need a big "Progress Through Quality" program to adopt right now real human relations techniques in your own personal program—not at all. There are so many things you can do easily, quickly and effectively. A man named James T. Mangan, writing a little booklet for salesmen called "Sell By Giving," listed many of them very neatly indeed. You may not be salesmen, but these points would apply to you as well in your work, in your home relationships, in every contact with people. Let me cover them briefly for you:

Mr. Mangan wrote: "Give, cause it doesn't cost you anything. Give the gift of attention." Listen to people attentively when they speak to you even if you are busy. To them, what they say is most important, and worth a few moments of undivided attention.

"Give the gift of praise"—a pat on the back or a word of praise does wonders to a man's morale and takes just a couple of seconds.

"Give the gift of consideration"—be considerate to others for we are all human.

"Give the gift of courtesy"—be polite, it's worth while.

"Give the gift of concession"—admit it, if you are wrong.

"Give the gift of good nature"—even if you have to load up with alka-seltzer the morning after, keep a sunny disposition. It's infectious.

"Give the gifts of confidence and faith."

"Give the gift of inspiration"—management is not all speeches; inspire your people with deeds as well as words. Be a leader.

"Give the gift of service"—run errands for your people, even your subordinates when you have an opportunity. Do not assume that "who are you to ask me, your boss, to run your errands for you" attitude.

"Give the gift of friendship"—you can give the gift of friendship and still be a supervisor.

"Give the gift of gratitude"—a 'thank you' only takes a split second but it is priceless.

"Give the gift of credit"—give credit where it is due. Don't steal ideas for it will work to your disadvantage eventually. You must develop the people under you, for as A. O. Malmberg writes, "Business is not the management of things, it is everlastingly the development of people, the selection, training, supervision, and development of people."

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Well, I've rambled on long enough. I can't predict the future of our industrial economy, except to know that it's changing all the time and the emphasis seems to be shifting to the human relations side after several decades of emphasis on technical and engineering phases. What the next shift will be, I don't know.

But I do feel this, sincerely; if you want to mount the ladder of success, if you want to get into more important over-all management from whatever your present position may be, you've got to develop those human relations techniques which will break you apart from a strict specialist classification, you've got to broaden your cultural business background, you've got to multiply your effectiveness by getting lots of other people to make "what you know" successful. Only people can start, stop, and do things. The people above you, beside you, around you, below you—those people will in truth make your success, if you will do the sound relations job that you can and should do.

Question: Mr. Dunning, what is your definition of success?

Answer: A successful man is one who has done something worthwhile and helped other people to do something worthwhile. Success is not measured by a man's paycheck. It means job satisfaction and job security. It means achieving something not for oneself alone but for others also.

Question: Mr. Dunning, how do you overcome the feeling among the men in the ranks that there is no chance of further promotion because the jobs above a certain level are filled with college graduates?

Answer: The answer to that is that you must develop the men in the ranks so that you can promote them. You must educate them for higher jobs. Those who are not capable of taking on higher responsibilities must be given extra rewards, a feeling of job satisfaction and job security must be instilled in them. We give big record-breaking dinners or parties to each unit in the plant which has exceeded the previous best performance record. People love to break records. Ninety-five per cent of the people are born with good sound human instincts and if those good instincts are appealed to properly, they will do the right thing always.

Question: Mr. Dunning, how do you reach every new employee?

Answer: We reach each and every new employee that we hire by giving him a period of indoctrination. We show him a movie, about Scott plants and people. We issue a booklet to him explaining our rules, operations, etc. We invite him to be our guest for his first meal in our cafeteria after which a representative of management talks to him.

Kalamazoo Valley

The Kalamazoo Valley Section of TAPPI opened its 1950–1951 program with a meeting at the Columbia Hotel in Kalamazoo on October 5. Eighty-five were in attendance for the dinner and evening program.

James Harrison, Chairman of the Kalamazoo Section, presided. After dinner he introduced J. R. Dam, program chairman, who in turn presented W. H. Bureau of the Butler Paper Co. of Chicago. Mr. Bureau spoke on the subject "Paper and Printing Problems from the standpoint of the Merchant and Printer." His remarks follow:

It would be difficult to find three industries more closely interrelated than are the paper, printing, and ink industries. They might be considered as constituting the three corners of a triangle which we will call the "Graphic Arts Triangle." A satisfactory product of the graphic arts, namely printed matter, represents the successful closing of the three sides of this triangle. It is our customer, the printer, who must do this when he commences his job.

Of the three sides of our triangle, paper is a constant, assuming any given sheet for a job. The other two sides, printing and inks, are variables. Thus, paper once made is unchangeable with one possible exception, and that is dimensional change, whereas, printing and ink each allow some adjustments which pressman and inkmaker can use in order to produce the best result on a given job. A few examples of the variables found in printing are: (1) makeready and printing pressure, (2) degree of etch of engravings, (3) press speed, (4) amount and distribution of ink, (5) adjustments with respect to feeding and delivery of sheets, and (6) conditioning of paper.

While the conditioning of paper is technically a paper variable, practically speaking, it becomes one of the printing variables.

Examples of variables existing in printing inks are: (1) degree of tack, (2) length and shortness, (3) color strength, (4) degree of gloss, (5) absorption of vehicle, and (6) drying rate.

Notwithstanding these helpful variables, there are times when the graphic arts triangle can't be successfully completed, the paper is said to be at fault and the situation resolves itself into a complaint or claim.

Someone has said, "as long as paper is made, there will be complaints." However, this is no reason for relaxing our efforts to reduce complaints to a minimum. It is only logical that the combination of variables prevalent in paper manufacturing, in printing, and in inks are bound to present difficulties at times. Since we are concerned with the greater elimination of complaints, let us attempt to analyze them from the standpoint of their causes. In so doing, we cannot confine ourselves to cases involving printing operations but must also include the end use requirements of paper.

General difficulties in the use of paper might be classified with respect to their cause as follows: (1) wrong paper selected for the job, (2) lack of complete information concerning paper requirements, (3) proper paper selected but actual delivery unsatisfactory, (4) difficulties attributed to printing operations, (5) difficulties attributed to inks, and (6) unexpected difficulties originating from unusual combination of circumstances.

1. Let us consider the first case "Wrong Paper Selected for the Job," with a few examples:

Several years ago, a lithographer complained a delivery of paper wouldn't run. His inks scummed and the sheet left a deposit on the blanket and plates. Investigation revealed he had ordered a carbonate E.F. which he or no lithographer could ever print successfully.

Recently, a printer complained that a shipment of coated paper gave poor reproduction in his letterpress halftones which was actually true. It was found he had used an offset enamel from his own stock. His intention was to purchase and stock one enamel, an offset enamel, for both his letterpress and offset departments. Naturally, it was explained that an offset enamel is not the proper coated paper for a fine letterpress job.

Then there was the case where a letterpress printer was trying to print heavy solids, and fine line matter on a ripple finish cover stock that had been chosen by his customer. The hard snappy cover stock with its pronounced ripple finish wouldn't permit satisfactory reproduction by letterpress. The only solution was to reproduce by offset on this cover stock or to select a softer paper with a different finish for letterpress reproduction.

2. The 2nd case, "Difficulties Arising from Lack of Complete Information Concerning Paper Requirements" is really an extension of the first case but treated separately in order to emphasize a common source of complaints which could be eliminated to a much greater extent. A few examples will illustrate that such complaints would never have arisen had sufficient information been provided with the order.

There was the case of an order specifying coated one side label for varnish. Mill shipped their standard starch C1S for varnish at the time. The job was lithographed and while some difficulty was experienced, the job was finished, no complaint being registered. The labels were applied to beer bottles and you can imagine what happened after they were immersed in water for a few minutes. No overprinting of varnish or ink would prevent the coating washing away from the base stock. Had the order specified "for beer label," this unfortunate incident would have been avoided.

Another example was a vivid purple patent coated cardboard manufactured in accordance with approved colored hand samples. The paper was intended for permanent wall placards and faded quickly because no mention was ever made of the end use and necessity for fastness-to-light.

3. The third classification of causes "Proper Paper Selected but Actual Delivery Unsatisfactory" is perhaps of more concern to you as manufacturers. As we review this case there seems to be two basic causes for unsatisfactory deliveries: (1) defects originating in manufacturing; (2) defects resulting from poor inspection and carelessness in finishing operations.

To illustrate the first source, recently a delivery of coated paper was lithographed in three colors. The first two colors were a yellow and red that covered only small areas of the sheet. The third color black was a heavy solid, almost complete coverage. The black had a washed out, gray appearance. Changing of ink and amount of ink run made no improvement. Examination of the coating revealed an excessive number of pin holes or porous structure. The job was run on a single color press and unfortunately the nature of the form for the first two impressions didn't disclose the condition of the coating. This job had to be rerun after microscopic examinations revealed the fault lay in paper.

There was another similar case on coated blotting. Again this condition didn't appear until several colors had been printed. Definite streaks appeared in lithographing a screen background that looked like roller marks or from some press condition. Rollers were changed, reset and the press gone over generally. Then it was discovered there were definite areas or streaks in the coating full of tiny holes. Rather than scrap the job, it was found cheaper to salvage it by running an extra impression of sizing over the entire sheet to seal over the defective surface and then proceed to complete the job.

Examples of carelessness and poor inspection are ever with us. Several years ago, a customer broke a large piece from the knife in guillotine trimming a delivery of paper because someone at the mill had made him a present of a section of iron strapping concealed among the sheets of a bundle.

Another customer smashed a plate because someone in the mill had dropped a crumb from a candy bar on a sheet which stuck thereto and fed through the press to cause a smashup.

We know of one original mill skid that caused damage to four offset blankets. A folded sheet went through a two-color press damaging both blankets. These were replaced and the job resumed. Before this same skid was finished, another concealed folded sheet damaged two more blankets. Not only were several hundred dollars of blankets involved but also considerable loss on time on a large press.

Once we were called to see why a carload delivery of Bible paper wouldn't go through a press. A few sheets would feed and then two sheets would apparently stick together jamming the feeder. The cause was sticky latex particles in the sheet. The mill used a latex splicing compound. In finishing operations, someone placed the splices in the "broke" box instead of the waste box intended for the boiler room. The beaters did a swell job of dispersing these latex particles throughout a carload delivery of paper which was promptly remade.

4. Recalling the many variables in printing it is to be expected there will be difficulties attributed to printing conditions.

Recently a delivery of C1S litho label was rejected because it curled in a very pronounced fashion toward the coated side in both directions after going through a two-color offset press. Yet the paper was perfectly flat in the feeder pile. The sword moisture indicator reading of the paper prior to printing was 43%, after printing 53%. The answer was an excessive amount of press moisture. This same lot of paper was delivered to another lithographer who reported no trouble in running same.

There have been several complaints registered on letterpress jobs that paper reproduced halftones poorly. Microscopic examination of coating and ink receptivity tests indicated paper was normal. One job in particular had a gloss yellow and a gloss blue run single color, consisting of mostly solids. Third color was a gloss black consisting of halftones. Halftones were duplicates, some of which reproduced satisfactorily, others of which didn't. Close examination showed that the accumulation of large size spray particles on the sheet after printing the first two colors was interfering with the printing of halftones dots—more in some areas than others, depending upon their concentration.

5. "Difficulties Attributed to Inks" do arise. There have been cases where paper was blamed when one of several colors printed failed to dry properly. Or possibly you have known of a case where the top few sheets on the pile dry with the original shade whereas sheets within the pile dry with a "burned out" color of different shade. This results from chemical changes which the ink pigments undergo depending upon combination of oxygen supply and heat generated in drying.

Problems involving ink arise after printing, such as in the bindery, and in mailing because rink rubs, mars or scuffs. This usually can be overcome by change in formulation, greater care in folding of paper and manner in which it is mailed.

6. Cases of "Unexpected Difficulties Originating from Unusual Combination of Circumstances" are not too common but very interesting.

Once we received an insurance policy that had been printed on rag bond. Inks appeared to have bled through and over the surface of the paper making the printing illegible. Question was raised whether some reaction had occurred between paper and ink. Paper was normal by all chemical tests and it was inconceivable that ink once having dried would bleed. Upon tracing the history of this policy, it was learned that it had been kept in a cedar chest and that oil of cedar and its vapor will dissolve printing ink.

Some years ago, a paper delivery was printed and found badly discolored at the edges upon standing in the press room over the weekend. Every test indicated nothing in the paper to cause discoloration so quickly. A thorough search revealed a new pressman had formulated his own press wash using aniline oil. The vapor of aniline oil discolors paper quickly.

During the paper shortage of the war, a customer called frantically for paper. The only paper in the warehouse was an old lot of newsprint which the customer agreed to run offset at his own risk. Apparently he got away with it. Sometime later he ordered newsprint with no mention of offset. This delivery came fresh from the mill and trouble began. He couldn't lithograph a repeat job on such a paper. His assumptions were false because the old lot of newsprint had developed some degree of sizing, which groundwood papers will do upon aging, and lithographed whereas the new lot was completely slack sized and gave trouble.

Our paper has even done a disappearing act. Some years ago, we made a local delivery of 50 reams 17 × 22 bond paper and the driver returned with a signed receipt. A day later the printer reported paper couldn't be found. Our salesman went through the plant even checking the waste crates to see if paper had been discarded by mistake but found no trace. Both sides being baffled a compromise settlement for the value was reached on the spot. A few hours later a call came from the printer solving the mystery. Seems that the janitor had been instructed to do some cleaning the night before and being a conscientious fellow found these 50 reams in his way whereupon he transported them to an unknown closet of another floor in the building.

We have only touched upon various aspects of this general subject and it is evident that a better appreciation of each others problems will promote closer cooperation among papermaker, printer and ink manufacturer. The modern printer and user of paper is fully occupied with his own problems exclusive of paper ones. It behooves you as manufacturers and we as merchants to keep his problems relating to paper as few and simple as possible.

After the speech by Mr. Bureau there was an open discussion of printing requirements.

Mr. Trelfa: From the printer's standpoint what are the major requirements for coated paper to be printed offset?

Mr. Bureau: First the coating must be suitable for printing mechanically and chemically, and second, the sheet must be dimensionally stable.

Mr. Trelfa: How is smoothness related to the suitability of the coating for printing?

Mr. Bureau: Smoothness of course is necessary, although in offset printing this is not as critical as in letterpress.

Mr. Trelfa: What are the most important ideals for letterpress then?

Mr. Bureau: First, an optically flat surface, and second, satisfactory and uniform ink receptivity.

Mr. Trelfa: What laboratory tests are best for determining this?

Mr. Bureau: Bonding strength is one of the most difficult to measure for the wax test is frequently misleading. In some cases paper with a high wax value will give more picking trouble than a sheet with a lower wax. Picking is also affected by the condition of the blanket; the older the blanket, the greater the pull on the sheet.

Mr. Trelfa: Can you correlate smoothness values with printing performance?

Mr. Bureau: There is no direct correlation, especially on coated papers, for letterpress printing requires a combination of smoothness, ink receptivity, and cushion.

Mr. Hall: How does machine-coated offset compare with brush-coated offset?

Mr. Bureau: Generally speaking, it compares very well. In some cases the machine-coated sheets lack dimensional stability, but this may be due to the fact that machine-coated sheets are generally lighter.

Mr. Trelfa: In machine coating you are drying the coat under tension on the fourdrinier. In conventional coating perhaps wetting the sheet in the coating operation relaxes strains developed on the fourdrinier.

Mr. Hamilton: Another difference is in the bodystock sizing. Machine-coated sheets are slack sized and may pick up more moisture in printing.

Mr. Luey: Producing the paper at the proper moisture content is probably more important than anything else in improving dimensional stability.

Mr. Bureau: In most cases if the mills could put a higher per cent moisture in their uncoated offset sheets, they'd have less trouble with dimensional stability. Probably the same generalization applies to coated sheets.

PHILIP E. NETHERCUT, *Recording Secretary*
Watervliet Paper Co., Watervliet, Mich.

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Soda pulp requires much more color to produce a given shade than is required for either bleached sulphite or bleached kraft. Both bleached and unbleached groundwood require even more color than soda pulp. Basic dyes give good color value on groundwood, but direct, acid, and pigment colors show poor color value.

In addition to the variations in color depth obtained on different pulps, these pulps also vary in brightness, and frequently in opacity. It is easy to realize how changes in the proportions of the pulps in the furnish will effect the shade and the uniformity during a color run.

Broke is another problem. It will vary considerably in color, shade, and pH and therefore should be handled with caution. By a careful selection of colors it is possible to mix all broke together and by the use of a hypochlorite bleach destroy sufficient color so that the broke may be worked off in all shades. In adding broke, bear in mind the color of the broke, the furnish of the broke, and the filler content. Blend a definite amount of broke in each beater in order to minimize its effect on the shade. When a change is made in the furnish, advise the color man so that he may expect the change and can make compensating adjustments.

Book stock made from deinked old papers will contain a high percentage of filler coming from the machine-coated papers. In some cases the filler may be chalk, although it will probably be clay. The stock may contain soda pulp as well as groundwood pulp. This type of pulp will therefore require more color per unit weight than a standard bleached suphite furnish.

FILLERS

Fillers are used in paper for a variety of purposes. They are being used to a greater extent today than before the war, largely for economic reasons. Fillers have an effect on depth, shade, opacity, and the two-sidedness of colored paper.

Clay is the cheapest filler and therefore the most widely used. Some colors have a strong affinity for clay. Other colors have a preferential affinity for the fiber. The Stilbene yellows will dye the clay in preference to the fibers. All fillers will concentrate on the top surface of the sheet because of the suction of the boxes and the suction couch roll. Therefore, colors that dye the filler preferentially will give a sheet more heavily dyed on the top surface.

Some dyes have a greater affinity for the fiber. These dyes may be called "bottom colors." They will produce a sheet more heavily colored on the bottom side when used in a heavily loaded sheet. Naturally, the degree of two-sidedness will vary with the selection of dyes used, the amount of filler, and the degree of filler retention. A recent experience in a mill running a mimeograph sheet demonstrated this point clearly. This mill was running a light pink shade dyed with

H. A. LIPS, Member TAPPI; Technical Laboratory, E. I. du Pont de Nemours & Co., Inc., Wilmington Del.

Crocein FL Extra Conc. The sheet was relatively non-two-sided even though it contained 10% clay. In an experimental run this mill added a special starch which increased the filler retention considerably. The sheet became very two-sided with the bottom more heavily dyed than the top side. This change in two-sidedness was caused only by the increase in filler retention. In order to eliminate the two-sidedness and still maintain the higher degree of filler retention, it would be necessary to change to a color with a more balanced affinity or to use a combination of a "bottom color" with a color that has a preferential affinity for the filler.

The outstanding "bottom colors" are:

Brilliant Crocein FL Extra Conc.	(C.I.—)
Ruby PL Extra Conc. 200%	(C.I.—)
Brilliant Paper Yellow Extra Conc., 125%	(C.I. 364)
Anthraquinone Blue BP, Blue BN	(C.I. 1054)
Quinoline Yellows	(C.I. 801)
Red 8BLX	(C.I. 278)

Talc behaves very much like clay, and as far as colored paper is concerned, the effect of talc will be about the same as an equivalent amount of clay.

Titanium dioxide has little attraction for dyes. It is the most opaque white pigment known and one of the whitest. When titanium is used, it is necessary to increase the amount of color to maintain the same color depth. The use of 4% titanium dioxide based on the weight of the fiber furnish means that almost 50 to 100% more color will be required. A change in the amount of the oxide in the sheet will materially affect the shade. The next time you want greater opacity in your sheet and plan to increase the titanium content of the furnish, advise the color man, because it will very definitely alter the shade and the color depth. Generally, titanium dioxide adds a bluish tinge to a colored sheet.

Chalk is used in some grades where a high pH is desired. It cannot be used in well-sized sheets because of its high pH. Some colors have a natural affinity for chalk, but most colors will not dye this filler uniformly. The best dyes for chalk fillers are:

Fast Yellow 4GL Conc.	(C.I. No. PR-53)
Brown CG Conc., 150%	(C.I. No. 598)
Bordeaux B Conc., 150%	(C.I. No. 375)
Blue AX Conc.	(C.I. No. 502)
Blue 3BX Supra	(C.I. No. 477)
Blue 3R	(C.I. No. 464)
Direct Black	(C.I. No. 581)

THE IMPORTANCE OF COLOR SELECTION

The importance of color selection cannot be overemphasized. Experience and observation are of prime importance. Color selection determines the cost of matching the shade, the properties of the sheet and, of course, the ease of control.

It is impossible to make a satisfactory color selection unless the properties required of the finished sheet are known. The importance of knowing the end use of the paper before making a color selection cannot be overemphasized. What will the paper be used for and what properties will be required of the sheet? Only with this information available is it possible to select colors that will match the shade as cheaply as possible, and still meet the necessary fastness requirements. Actually, without this information it is difficult for a mill to select the proper pulp furnish. If this information is not available, invariably the mill will use more expensive colors which may even be more difficult to control in order to make certain that the fastness of the sheet will be satisfactory. Your competitor may know the end use and be able to use a much cheaper color formula for the same shade.

A few examples in regard to color selection may prove this point. Formerly, all bond grades of envelope paper had to be fast to alkali because of the alkaline adhesives in common use. Today a large envelope manufacturer advises that all their adhesives are on the acid side. Therefore, Brilliant Paper Yellow (C.I. No. 364) is satisfactory. This color is one of the cheapest yellow dyes available. It has very good light fastness, is essentially non-two-sided, and handles well in the mill. It is extremely sensitive to alkalies. When alkali fastness is not a factor the use of Brilliant Paper Yellow is economically feasible. The same goes for Benzo Purpurine (C.I. No. 448) which may often be used in place of Crocein FL Extra Conc. (C.I.—) where the excellent properties of the latter color may not be required.

Basic dyes are the cheapest and brightest. Their light fastness is poor. They will granite in a mixed furnish and have little or no affinity for bleached pulps. Acid and direct dyes vary considerably in properties within their own class. Some acid dyes such as Crocein FL Extra Conc. have excellent light fastness. Others such as Green BL Extra Conc., 200% (C.I. No. 666) have poor light fastness. This particular color is used for brilliance only. The same variations may be found among the direct dyes. It is therefore essential to know the properties of the individual colors as well as their class characteristics in order to make a proper color selection. As an example let us consider a case of two-sidedness. If we made a gray with a non-two-sided yellow and a non-two-sided red and then used a two-sided blue pigment such as iron blue as the shading agent, the bottom side would be a tan in contrast to the gray top surface.

Again let us emphasize the importance of knowing the end use of the paper and the properties of the individual dyes.

Some colors have a slow rate of development. This means that a reasonable amount of time in the beater is required to obtain full-color value. This is true of all pigments, particularly the inorganic pigments and those that are poorly dispersed. Slow rate of development is also a characteristic of Nigrosine and the Anthraquinone Blues. These colors develop full value in about 30 minutes after the addition of the alum.

When pigments or these soluble colors are used in a color formula it is desirable to control the beating time, particularly the time in the beater or in the chest after the addition of alum.

The Influence of pH

Most dyes work best within definite pH limits. Fortunately, these limits are generally fairly close to the pH limits for optimum sizing. In some cases, however, the pH limits may be noticeably different than those for sizing. These colors are usually used because of their specific properties or for economic reasons. An outstanding example of this point is Benzo Purpurine, which should be dyed at a pH of 6.0 to 6.5. This color requires careful pH control. The most important properties of this color are brightness and economy. If it were not for the economy factor, this color would only be used to a limited extent because of the high pH necessary to develop the bright shade.

Whenever possible, the dye should be used within its optimum pH limits. The pH affects retention, shade, and lightfastness. Most direct blues are greener and brighter at high pH values than at 4.0 to 4.5. Most colors have better light fastness at a pH from 6.0 to 7.0 than at low pH values.

Sizing

The type and degree of sizing will influence retention and lightfastness. In dyeing acid colors, both size and alum are required to retain the color. In deep shades an increase in both size and alum will aid retention. An increase in the amount of alumina ion either as alum or as sodium aluminate will aid in holding large amounts of direct and pigment dyes. Some control of these variables is essential for maintaining a uniform shade.

Starch is often added as an auxiliary sizing agent. Starch will weaken certain shades. Some dyes have a greater affinity for starch than for cellulose. These dyes will dye the starch as well as the fiber. This cannot be noticed in most cases as long as the starch becomes completely dis-

solved. If the starch remains highly swollen and does not completely dissolve, the sheet may appear to have colored dye specks. At first glance these specks appear as undissolved dye, actually they are dyed starch.

ORDER OF ADDITION

Order of addition is one of the common causes of trouble in shade control. A high percentage of the complaints in regard to color uniformity may be traced to changes in, or improper order of addition.

Dyes may be added before or after the size, but for all practical purposes, they should be added before the alum. This is particularly true of direct dyes. A rule in the mill covering this specific point will be very helpful.

In a recent mill run the importance of this point was demonstrated. The mill was running a medium yellow shade and complained of serious shade variations. They were using 5 pounds of Stilbene Yellow G Conc. per 1000 pounds of bleached sulphite. The color was being added after the alum. The order of addition was reversed and the color formula was cut to 2 pounds 12 ounces to compensate for this change. The shade was somewhat greener, noticeably brighter, and held constant from then on.

The importance of correct order of addition is often clearly understood by the superintendent and the technical department, but they fail to impress this on the color man or the beater room men. It is common practice to use a beater furnish form listing the pulps in use in the mill at the top, followed by the fillers, size, alum, and color in that order. The dyes are invariably listed last since the list may be fairly long. Many beater-room men follow the exact order of addition as shown on this log sheet even though the log sheet was not meant as the time table for these additions. These mistakes are made because the men do not realize the importance of the order of addition. Direct dyes are the sodium salts of dye acids. Many direct colors are only partially soluble in acid solution. They are generally much more soluble in an alkaline medium. Therefore, by adding the color before the alum it has an opportunity to dissolve before the beater is acidified. We generally cannot expect to obtain full value when the color is added after the alum. Naturally, there are many exceptions but, as a safety measure, insist on adding dyes before the alum.

MECHANICAL ADJUSTMENTS

The manner and degree of pulp preparation will materially affect the shade and color depth as well as the physical properties of the sheet. A highly beaten pulp will show much more apparent color strength than a free or partially beaten pulp. Hydration assists in mechanically and physically holding color, but the chief difference is in optics. The well-beaten pulp, although it appears much more heavily colored when viewed on the surface, will appear not much stronger than the partially beaten pulp when viewed by look-through.

In the mill a change in the jordan setting may alter the shade as much as 10 to 20%.

The suction couch roll, the suction boxes, and the table rolls are used to remove as much water as possible from the sheet before it goes to the presses. This dewatering equipment, especially the vacuum equipment, also removes short fibers, fillers, colored pigments, and soluble dyes from the sheet. This equipment draws these materials from the bottom side of the sheet and thereby promotes two-sidedness. Many mills never had a two-sidedness problem until they installed a suction couch. Naturally, a change in the amount of suction on the couch roll and the boxes will affect the shade and the degree of two-sidedness.

In most mills the drying conditions are such that the driers will not adversely affect the shade, but in some cases, particularly in board mills, the high temperature of the driers will cause some colors to burn to the surface. This is particularly true of acid colors, but some direct dyes also show this tendency. It is primarily encountered with those dyes that are least firmly fixed on the fiber.

The writer observed an interesting illustration of burning to the surface during a recent mill run of index board. The mill was attempting to run a green shade by shading iron blue with a direct yellow. In this case the yellow was not exhausted completely on the fiber and when the color hit the hot driers the yellow burned to the surface, leaving the inside blue.

While discussing the driers it might be well to mention the importance of cooling a sample before judging the shade. Many colors change shade to some extent as the sample cools. If a judgment is made on the basis of a "hot" sample it may be very misleading. Allow at least five minutes for the sample to come to equilibrium before comparing against the standard.

The calenders will also have some effect on the shade. An uncalendered sheet will appear weaker than a calendered sheet. A water finish will increase the strength as much as 30%, and a water finish coupled with severe calendering may double the color strength.

STANDARD LIGHT FOR JUDGING SHADES

The best lighting for judging shades is northern morning daylight. Even daylight varies considerably from morning to afternoon. Despite many attempts, industry has not been able to develop a lamp that in every way duplicates morning sunlight. Since matching shades in a mill is a 24-hour occupation, it is essential to establish a standard lamp which will be used for all shade matching. If the day shift uses daylight and the night shift uses artificial light, trouble in shade control is bound to develop.

Many colors turn shade considerably when viewed under artificial light. Violets, in general, turn considerably redder under artificial light. Methyl Violet is outstanding and turns almost to a red under artificial light. Methylene Blue and Prussian or Iron Blue turn considerably greener. To eliminate the possible trouble that may occur due to artificial light change from one shift to another, use a single lamp for judging all shades. It is best to enclose this lamp in a booth that is kept clean and preferably painted white or black. The booth should be large enough to provide good visibility for two or more observers.

A few mills today insist on a spectrophotometric match before accepting a color formula for mill use. In this way they are assured that the new formula will produce a shade which will appear the same as the sample to be matched when viewed under different lights. However, the formula developed on the basis of a spectrophotometric curve may prove to be more expensive.

One of the best ways to reduce variations caused by an artificial light change is to match the shade as closely as possible with colors having the same or similar change. As soon as a sample from the machine matches the shade in question, remove the original sample and match all future production to the new standard made in your own mill. This will eliminate the question of artificial light change and will be easier to match for subsequent shifts because of similar paper characteristics.

In conclusion, the writer would like to re-emphasize the importance of controlling the furnish, filler content, sizing, pH, beating time and suction on the machine to maintain a uniform shade. Bear in mind the effect that these changes will have on the shade. If you have a control laboratory, have the laboratory assist the color man, advise him of what to expect from certain pulps and fillers. Also, advise him of mechanical changes that are to be made and advise him in advance. Remember that the ultimate consumer will notice the color before he is aware of the sizing or any of the physical properties of the sheet.

PRESENTED at a meeting of the Kalamazoo Valley Section of TAPPI, Kalamazoo, Mich., Dec. 1, 1949.

Instrumentation Studies LIX. Tearing Strength of Paper

II. The Brecht-Imset Through-Tear Tester

K. W. HARDACKER and J. A VAN DEN AKKER

The Brecht-Imset through-tear tester is an instrument designed to measure the tearing strength of paper when it is subjected to a continuing tear. Following a description of the instrument and of the way in which it operates, a theoretical analysis of the method is presented. The mechanics of the Brecht-Imset tester were studied, with particular emphasis on the evaluation of instrument constants and the investigation of the quality of agreement between the theoretical and observed instrument indications. Good agreement was observed for most, but not all, of the instrument's range. Seventeen different types of papers were tested in a study of the tearing behavior of specimens torn in the Brecht-Imset and Elmendorf-Thwing testers, and the data obtained were compared. Because of the difference between the ranges covered by the two instruments, different numbers of specimens were simultaneously torn in the two testers. In general, the quality of tear (as regards splitting of the paper) was somewhat superior in the specimens torn with the Elmendorf-Thwing tester. Constant width of the zone of splitting was not observed in the use of the Brecht-Imset tester, where the paper under test had a tendency to split. The advantageous claims which have been made for the Brecht-Imset mode of tearing were not confirmed. The testing of thin, lightweight papers with the Brecht-Imset tester was attended with considerable difficulty, and in many cases a test could not be performed without considerable care on the part of the operator. Certain heavy papers are difficult to test, or cannot be tested at all, because of the tendency of the tear to progress out to the side of the test specimen when the Brecht-Imset mode of tear is employed. Relatively little difficulty was encountered in the testing of writing, book, and other papers of ordinary weight. The correlation between the data obtained with the two testers was fairly good, even to approximate numerical agreement in the testing of several types of papers. The results of a study of the influence of the number of specimens simultaneously torn are given. The degree of splitting observed in the use of both instruments was strongly dependent on the number of sheets simultaneously torn.

INSTRUMENTATION Studies XLVI (*1*) contains a discussion of the property of tearing strength (variously referred to as "continued tear" or "through-tear") and presents a theory of this property of paper; a section is devoted to the Elmendorf-Thwing tearing tester and 23 pertinent literature references are given. Of the latter, three references are to publications by Brecht and Imset dealing with their theoretical considerations of tearing strength and a new instrumental method, of which the instrument studied, manufactured by the Lorentzen and Wettre Co. of Oslo, Norway, is an embodiment.

Among the claims made by Brecht and Imset for the mode of tearing of paper employed in their method is constancy of the width of "skinning" of the paper during the tear. They contend that the degree of skinning is variable in the early part of tearing, but remains constant after a certain distance of tearing. Accordingly, they have developed an instrument which produces an initial tear through a fairly definite distance just prior to the measurement of the tearing strength. (The instrument measures nothing during this pretearing of the specimen.) The instrumental pendulum is then released, and the instrument indicates the through-tear resistance of the specimen over a further interval of tear. This possible advantage of the Brecht-Imset method of measuring tearing strength, coupled with favorable reports concerning the instrument in actual use in Europe, prompted the inclusion of this study on the instrumentation program.

K. W. HARDACKER, Technical Assistant, and J. A. VAN DEN AKKER, Member TAPPI; Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

DESCRIPTION OF THE BRECHT-IMSET THROUGH-TEAR TESTER

A photograph of the instrument investigated in the present study is presented in Fig. 1. On inspecting this picture from left to right, the reader first sees a compound pendulum comprised of a wheel to which is attached a massive disk and a handle.* The pendulum is shown in its cocked position, at a time just after the specimen (located at the front of the instrument) has been given the initial tear, and just prior to the actual testing of the tearing strength of the specimen. The pendulum is released by a slight rotation of the upper of the two knurled knobs at the right side of the instrument. When the pendulum rotates, a thin metal bar or ram ("Schrieber") emerges from a vertical slot in the specimen face of the instrument, causing a central zone of the specimen to be bent around the leading (blunt) edge of the ram and to be torn away from the rest of the specimen. This movement is effected by means of a gear on the pendulum shaft which engages teeth in the top edge of the ram. The zones of the specimen which were contiguous with the central zone prior to the tear are held back by means of fixed metal fingers attached to the specimen face plate. These fingers contact the specimen along a vertical central line, over a distance of about 0.5 inch down from the top edge of the specimen, and a similar distance up from the bottom edge.

The specimen is torn along two lines and four regions of rupture are involved in the tearing process. The initial tear causes the specimen to be torn a distance L in each direction away from the central vertical line, in each of the two lines of tear; thus, the total distance of tear (during the initial tearing action) is $4L$. When the pendulum is released and the tearing strength is measured, the distance of further tear in each direction, in each line of tear, is L'. Unlike the Elmendorf-Thwing tester, in which the distance of tear is fixed, the Brecht-Imset instrument produces a total length of tear of $4L'$ which is not fixed but depends

* The rim of the pendulum wheel has been equipped with a steel measuring tape, the purpose of which is explained later; the tape is not needed in the normal use of the instrument and is not supplied with the device.

on instrumental constants and the tearing strength of the paper. However, the method is such that the instrumental reading yields the energy expended in tearing the specimen through unit distance (gram-centimeters per centimeter), irrespective of whether L' is small (strong specimen) or large (weak specimen).

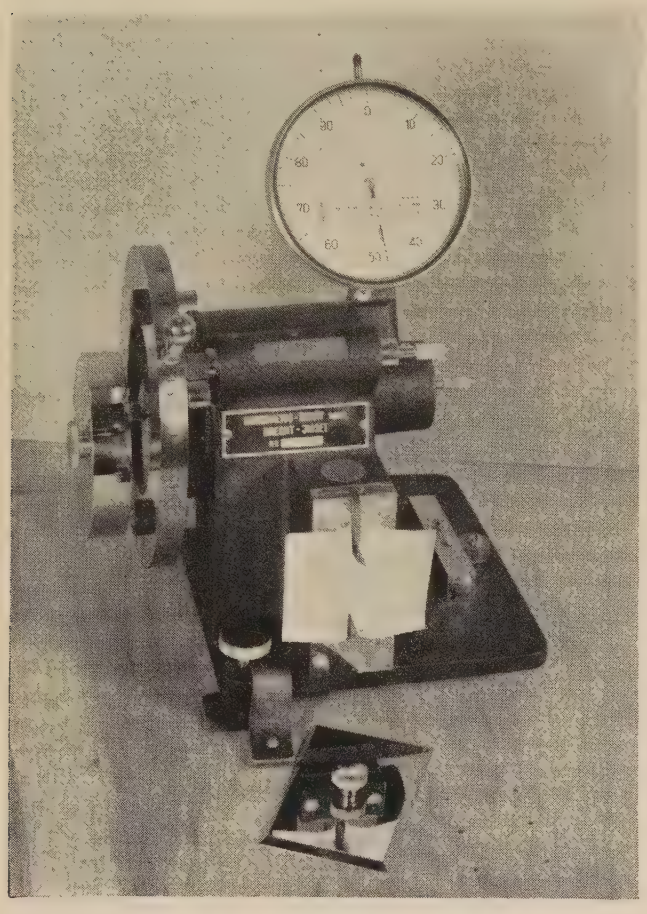

Fig. 1. Front view of the Brecht-Imset through-tear apparatus

A specimen which has been given the initial tear is in the instrument. The steel tape shown on the pendulum wheel was installed for special purposes.

The indicator of the instrument is essentially a dial micrometer. The foot of the sensing rod of this micrometer rides on a cam which engages the right end of the pendulum shaft. This cam, which has low pitch, is so figured that the final dial reading is directly proportional to the average work done in tearing a unit length of the specimen (that is, total energy expended in gram-centimeters divided by $4L'$). According to the manufacturer, this quantity, expressed in gram-centimeters per centimeter, is obtained by multiplying the dial reading of the particular instrument studied by 5.02.

Before making a series of measurements, the instrument is leveled with the help of the spirit level mounted on the base of the instrument, and the zero of the dial is adjusted. The latter is accomplished in the following manner. With no specimen in place, the pendulum is cocked as shown in Fig. 1. Then by means of the lower knurled knob at the right of the instrument, the cam is manually turned counterclockwise, as seen from the right) until it engages the pendulum shaft. At this point, the indicator will read in the neighborhood of 150 divisions. On being released, the pendulum will swing freely through its rest position to an angular displacement almost equal to its initial angle. During this swing, the foot of the dial micrometer will ride on the cam, and the indication will be reduced to approximately zero at the end of the swing. (The cam then remains disengaged and the dial indication remains constant while the pendulum swings to rest.) The dial is rotated to read zero and the operation is repeated several times to ensure that an average setting of zero is obtained.

In making a test, the pendulum is held in its uppermost position (ram completely retracted), one or more specimens are inserted, the pendulum is lowered to its starting position (the initial tear is produced), the indicator cam is engaged, and the pendulum is released. The indication remaining on the dial is then multiplied by the constant for the particular instrument to obtain the tearing strength of the one or more specimens. The manual manipulations involved in making a test are simple and can be carried out quickly.

It will be seen from the foregoing description that the Brecht-Imset through-tear tester, like the Elmendorf-Thwing instrument, measures an expenditure of work per unit distance through the use of a compound pendulum. The allowance for friction in the instrument is made through a zero adjustment of the indicator in a manner analogous to that employed in the use of the Elmendorf-Thwing instrument. In addition to differences in details of instrument design, the essential differences between the two methods are: (1) In the Elmendorf method a single tear of predetermined length is produced, whereas in the Brecht-Imset method tearing proceeds at each end of two lines of tear over a

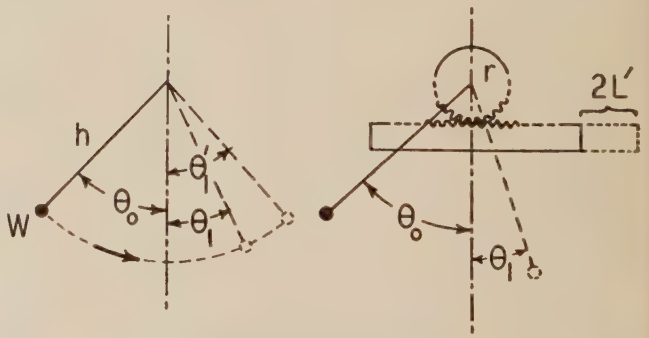

Fig. 2. (Left) Schematic diagram illustrating the angles employed in the theory

The center of mass of the pendulum weight is h distance from the pendulum axis. The pendulum swings to angle θ_1' when no specimen is in the instrument, and to an angle θ_1 when a specimen is torn.

Fig. 3. (Right) Schematic diagram showing the relationship between the angle of the pendulum and linear movement of the ram

distance which depends upon instrumental constants and the tearing strength of the paper. (2) In the Elmendorf method the energy expended is divided by twice the predetermined length of tear to yield a dial indication of the average tearing *force* in grams, whereas in the Brecht-Imset method the dial indication is pro-

portional to the *energy expended per unit distance of tear;* thus, the latter is of the order of magnitude of twice the Elmendorf indication. (3) In the Elmendorf method the point of onset of tearing is determined by an initial cut made with a sharp knife built into the instrument, whereas in the Brecht-Imset method the tear is initiated with a preliminary tear of appreciable extent.

THEORY

Considerations of the change in potential energy of the compound pendulum and of the loss in mechanical energy through friction are the same as those leading to equation 3 of Instrumentation Studies XLVI for the Elmendorf-Thwing tester. In the cocked position of the compound pendulum, the potential energy of the pendulum (relative to that of the pendulum in its rest position) is

$$\text{Initial energy} = Wh(1 - \cos\theta_0) \qquad (1)$$

where W is the weight of the pendulum, h is the radial distance to the center of gravity of the pendulum, and θ_0 is the initial angle (this and other angles are expressed in radians)(see Fig. 2).

$$\text{Final energy, no specimen} = Wh(1 - \cos\theta_1') \qquad (2)$$

$$\text{Final energy, specimen in} = Wh(1 - \cos\theta_1) \qquad (3)$$

where θ_1' and θ_1 are, respectively, the final angular swings when no specimen is in the instrument and when a specimen is torn. If Q' is the average frictional torque when no specimen is in place, the energy dissipated in friction is $Q'(\theta_0 + \theta_1')$, and this should be equal to the difference between the initial and final energies of the pendulum (difference between the expressions given in equations (1) and (2)):

$$Q'(\theta_0 + \theta_1') = Wh(\cos\theta_1' - \cos\theta_0) \qquad (4)$$

Similarly, the energy dissipated in friction when a specimen is in place is

$$Q(\theta_0 + \theta_1) = Wh(\cos\theta_1 - \cos\theta_0) - E \qquad (5)$$

where Q is the average frictional torque when the instrument is under load and E is the energy required to tear the specimen. The equation given by Brecht and Imset (*2*) for their instrument is evidently based on the assumption that the average frictional torque is independent of the load imposed on the instrument parts—that is, they have tacitly assumed that $Q = Q'$. This would not seem to be a valid assumption, because the frictional forces in the rack and pinion portion of the instrument should be proportional to the load under which the ram operates. It is possible that error arising in this assumption is of second order smallness. If we assume that $Q = Q'$, and substitute the expression for Q' obtainable from equation (4) in equation (5), we obtain for E the expression given in equation (6).

$$E = Wh[(\cos\theta_1 - \cos\theta_0) - (\cos\theta_1' - \cos\theta_0)(\theta_0 + \theta_1)/(\theta_0 + \theta_1')] \qquad (6)$$

Brecht and Imset have designed their apparatus to indicate the energy required to tear the paper through unit distance (as opposed, e.g., to indicate the average tearing force). The energy E given by equation (6) is the work done in tearing the paper in four zones over a distance of L' in each zone. It is clear that, to tear the paper over a distance of L' in each zone, the ram must move a distance of $2L'$. However, the movement of the ram (see Fig. 3) is $(\theta_0 + \theta_1)r$, where r is the effective radius of the gear engaging the ram. Accordingly,

$$2L' = (\theta_0 + \theta_1)r \qquad (7)$$

The total distance of the paper which is torn (that is, the total distance along the sheet traveled by the four regions of rupture) is $4L'$. Dividing this distance, expressed as $2(\theta_0 + \theta_1)r$, into the energy expended by the instrument, one obtains

$$A_D = E/2(\theta_0 + \theta_1)r \text{ g.-cm./cm.} \qquad (8)$$

in which E is given by equation (6) and A_D is the instrument indication. Except for minor differences in form and nomenclature, this equation is in agreement with that given by Brecht and Imset (*2*).

To obtain the average *force* per tear, it is noted that the average force exerted by the ram is equal to the quotient of E and the distance moved by the ram or, if F is the force for each of the four tears,

$$4F = E/2L' = 2A_D \text{ grams} \qquad (9)$$

from which we obtain

$$F = 0.5A_D \text{ grams} \qquad (10)$$

Equation (10) is employed in comparing the numerical indications of the Brecht-Imset and the Elmendorf-Thwing instruments.

One assumption underlying the theory (concerning the equality of frictional torques in the loaded and unloaded instrument) has already been discussed. Another, perhaps vulnerable, assumption is that the ram movement is equal to $2L'$. This implies that the torn zones of the specimen lie close to the sides of the ram so that, being parallel to the ram, the latter moves exactly twice the distance of tear. Actually, the stiffness of the paper causes the specimen to bend with appreciable radius of curvature during the tearing, so that the torn zones meet the ram in an acute angle. The magnitudes of this effect and of the resulting error depend on the stiffness of the paper under test. The stiffness of many papers is such that the angle is small and the cosine of the angle is close to unity; for example, $\cos 10° = 0.985$ which departs from unity by 1.5%—yet, 10° would appear to an observer to be an appreciable departure from parallelism.

The cam on which the foot of the dial micrometer rides is figured in accordance with equation (8) (with the value of E substituted from equation (6)). The agreement of fit of the cam with theory, together with other instrumental factors, is discussed in the next section of this report.

INVESTIGATION OF THE MECHANICS OF THE BRECHT-IMSET TESTER

Inspection of equations (6) and (8) shows that a study of the mechanical aspects of the Brecht-Imset instrument requires information on Wh, determination of the angle of the pendulum, and determination of r (effective radius of the gear engaging the ram); it is also evident that it is necessary to study the relationship between the angular movement of the pendulum and the dial reading.

The angular position of the pendulum was accurately measured by means of the following arrangement. An

accurate steel measuring tape was tightly wrapped around the rim of the pendulum wheel, as shown in Fig. 1. This was observed by means of a telescope equipped with cross hairs, which was rigidly mounted on a plywood base plate that also supported the instrument. If R is the sum of the radius of the wheel and the

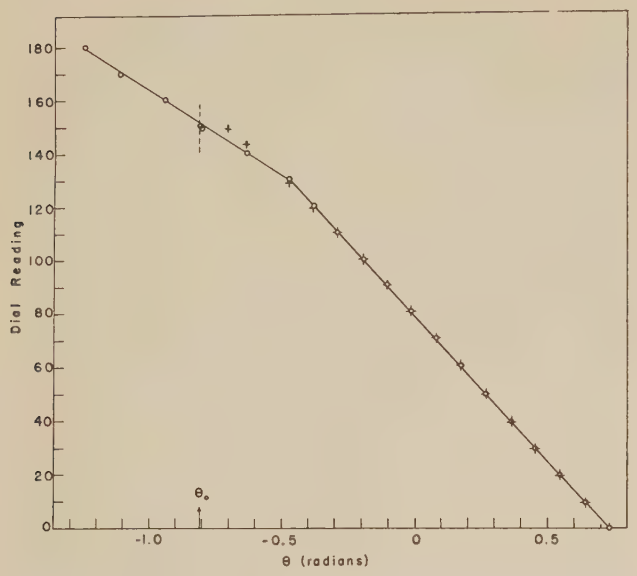

Fig. 4. Relationship between the instrument dial reading and the angle of the pendulum (this relationship describes the shape of the cam on which the foot of the micrometer rides)

The observed points are designated with o, and the desired theoretical shape is given by +; the latter is calculated from the theory presented in the text.

thickness of the steel tape, and S is the arc distance as determined with the telescope and steel tape, then the corresponding angle is given simply and accurately by $\theta = S/R$ radians. Angles were measured from the rest position of the pendulum, which was determined with the usual precautions to eliminate the effects of friction.

The product Wh was determined by means similar to that employed by Brecht and Imset—namely, the well-recognized method of suspending a weight from a compound pendulum, in a line of action at a known horizontal distance from the axis of rotation. If a fine fish line is passed around the periphery of the wheel (radius R) and a load P is suspended from the line, the pendulum will come to rest at some angle φ (again, the effects of friction are eliminated). It is readily seen that $Wh = PR \sin \varphi$. In this manner, it was determined that $Wh = 7920$ gram-centimeter for the particular instrument studied.

In the determination of r, the effective radius of the gear engaging the ram, and in an investigation of the relationship between the angle of the pendulum and the dial reading, the massive disk was removed from the pendulum wheel. A small length of spring steel was arranged to bear against the wheel, so that the wheel would remain in any position in which it was set. In the determination of r, a 25-inch Brown and Sharpe height gage, equipped with a vernier reading to 0.001 inch, was placed in alignment and in contact with the ram. The pendulum was then set at a number of angles covering a range somewhat greater than that involved in actual use of the instrument, and careful observations were made of dial reading, angle, and ram displacement. Throughout this work, the ram was under a small load, so that backlash was eliminated. An accurate plot of ram displacement versus angle was then made. In accordance with the relationship, ram displacement $= r\theta$, a linear plot was obtained. From the slope of this plot, it was found that the effective radius of the gear engaging the ram was $r = 3.485$ cm.

Observations on the relationship between the dial reading and the angle of the pendulum are given in Fig. 4. It will be seen that the data fall quite accurately on two straight lines, suggesting that the cam was ground to fit a spiral following the relationship, radius $= a + b\theta$, over one portion and another spiral, radius $= a' + b'\theta$, over the remaining active portion. The theoretical relationship, computed with the help of the theory presented in the previous section (employing instrumental constants measured in this study), is also shown in Fig. 4. As might be expected, the theoretical relationship is curved. However, it is apparent that the manufacturer has fitted the pair of spiral grindings to the theoretical relationship in an ingenious manner; the agreement is good over the range commonly employed, and significantly imperfect only over a range from about 120 to 150 dial divisions (corresponding to tearing strengths near the top limit of the instrument). In the latter range, the error is of the order of 1 to 2%. A more massive disk may be attached to the pendulum to yield indications less than 120 divisions in the testing of stronger papers.

The computed work per unit distance of tear, A_D, is plotted against dial reading in Fig. 5. For the purposes of comparison, the relationship supplied with the instrument is given by the dashed curve. The computed relationship is seen to be accurately linear over the greater part of the range, the deviations of appreciable magnitude beginning at a dial reading near 125 divisions, corresponding roughly to the break in the cam-shape curve given in Fig. 4. According to our data, the manufacturer's factor, 5.02 gram-centimeters per centimeter, is too high by nearly 2%. Although this error is somewhat smaller than typical specimen variation, it is ordinarily considered good principle to maintain the instrumental error within a small fraction of the standard error observed in the testing of paper. This effort should be made in the interest of producing instruments which will agree with each other when employed in different laboratories. It is possible that the manufacturer can supply a calibration procedure which could be employed in the mill laboratory for periodic check on the instrumental constant.

The probable dependence of instrument friction on the ram loading (discussed in the section on theory) was not checked directly. Relative to the Elmendorf-Thwing instrument, the internal friction in the Brecht-Imset tester is rather large. Even with the cam disengaged, the pendulum swings to rest in about 14 half-oscillations. Since the damping in this instance is due to Coulomb friction, the decrement in angular amplitude should be nearly constant from one half-oscillation to the next half-oscillation; accordingly, the decrement per half-oscillation is about $0.8/14 = 0.06$ radian $= 3.3°$ (the initial amplitude θ_0 is 0.808 radian). Hence, if the dependence of internal friction on ram

loading is appreciable, the error arising from this cause could be significant. A more serious observation relative to the instrument friction was the variability of the friction. After the instrument had been in a testing room maintained at 73°F. and 50% relative humidity for several weeks, rusting of the ram was noted, and increased friction was observed after the instrument had been idle for two or three days. Further use decreased the friction. The zero adjustment was, of course, made

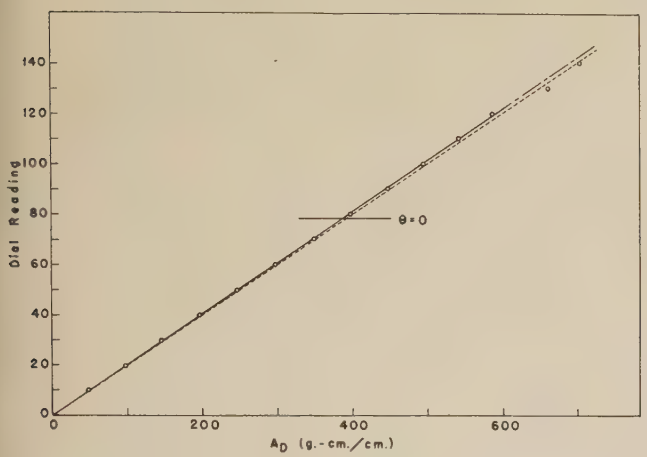

Fig. 5. Relationship between the instrument dial reading and the energy required to tear unit length of the specimen

The relationship shown by the dashed line is the product of 5.02 and the dial reading.

at frequent intervals, but zeroing of the instrument cannot be expected to ensure accuracy if the frictional torque varies too widely from the value for which the cam is figured. Instrument friction can be checked from time to time (as in the calibration of the Elmendorf-Thwing tester) by counting the number of half-oscillations which the pendulum will execute in coming to rest from its cocked position.

Table I. Dependence of the Zero on Operator Variability

Speed of release	*Cocking of pendulum*	*Engagement of dial cam*	*Average zero*	*Mean deviation*
Slow	Hard	Gentle	1.0	0.5
Quick	Medium	Medium	0.6	0.4
Slow	Gentle	Hard	0.5	0.4
Slow	Medium	Medium	0.4	0.2
Quick	Hard	Hard	0.4	0.3
Quick	Gentle	Gentle	0.0	0.3
Quick[a]	Gentle	Gentle	−0.2	0.4
Quick[b]	Gentle	Gentle	−0.3	0.5

[a] Pendulum released 2 seconds after being cocked.
[b] Pendulum released 15 seconds after being cocked.

The constancy of the zero reading, for a given dial setting, is inferior. To investigate this defect, 80 determinations of the zero were made under varying conditions of manual operation. In some cases, the pendulum was released from its cocked position with a quick snap of the release mechanism and, in other cases, with a slow release. The pendulum and/or the dial was brought against its stop with hard, medium, or gentle impact. These conditions were intended to cover the range of handling to be expected from different laboratory operators. The data obtained are given in Table I. Ten observations were made for each set of conditions. It is evident that operator variability can account for a spread in the zero of about 1.3 dial divisions. This variability alone could account for the following possible errors: 10% for a dial reading of about 13 divisions, 5% for about 26 divisions, 2% for about 65 divisions, etc. Under the most steady operator conditions (which are not to be expected in practice), the variability in the zero is about 0.4 division (average of the last column).

Leveling of the instrument base is critical in its influence on accuracy only with regard to an axis parallel to the pendulum axis. A spirit level rigidly mounted on the base provides for sufficiently nice leveling about such an axis. A spirit level has not been provided for the other principal horizontal axis, presumably because leveling by eye with regard to that axis is sufficient. Only a small "cosine error," proportional to the difference between unity and the cosine of the angular uncertainty (perhaps a few degrees), is involved and it could be neglected.

It was found necessary to mount the instrument rigidly on a heavy plywood base plate which, in turn, was clamped to a heavy rigid table. This is a precaution which should be observed in the mounting of any device that utilizes a swinging pendulum for the measurement of the energy required to tear, break, or otherwise rupture a material; if an instrument of this class is not so mounted, an appreciable error will result because of the energy lost in moving and deforming the faulty supporting structure.

STUDY OF THE APPLICATION OF THE BRECHT-IMSET TESTER TO THE TEARING OF A SERIES OF PAPERS

In order that the claims made for superior tearing characteristics obtained with the Brecht-Imset instrument could be investigated, 17 different types of papers, covering a wide range in furnish and weight, were selected for measurement and observation of the nature of tearing with both the Brecht-Imset and the Elmendorf-Thwing tearing strength testers. These papers are described in Table II.

Table II. Description of Papers Tested

Sample	*Furnish*	*Basis weight (25 × 40—500), lb.*	*Caliper × 10^{-4}, in.*
1	Tablet, sulphite	36.0	38
2	Sulphite	53.1	40
3	Cotton, 75%	27.2	22
3a	Different batch of paper 3	25.5	21
4	Rag	54.8	38
5	Rag	67.7	50
5a	Different batch of paper 5	67.8	51
6	Unbleached kraft	49.3	44
7	Unbleached kraft	51.7	53
8	Unbleached kraft	80.5	88
9	Book, uncoated	35.9	28
10	Book, coated, supercalendered	53.3	29
11	Newsprint	37.5	36
12	Glassine	25.8	24
13	Glassine, supercalendered	28.6	12
14	Condenser tissue	9.5	7
15	Bible	20.9	15
16	Blotter	117.0	211
17	Tablet, sulphite	42.1	29

Table III. Results and Observations on the Tearing of Paper with the Brecht-Imset and Elmendorf-Thwing Testers

	Brecht-Imset		*Elmendorf*		*Brecht-Imset*		*Elmendorf*	
	M.D.	*C.D.*	*M.D.*	*C.D.*	*M.D.*	*C.D.*	*M.D.*	*C.D.*
	Sample 1				Sample 2			
Number of sheets torn simultaneoulsy	2	2	4	4	2	2	4	4
Number of tests	8	9	5	5	5	5	4	3
Average instrument reading	20.9	25.1	7.7	9.4	36.1	34.7	8.7	10.3
Average deviation	1.3	1.3	0.4	1.0	3.8	1.2	0.8	0.2
Percentage deviation (individual values)	6.4	5.0	4.8	10.0	11.9	1.7	6.6	1.7
Force in grams to tear single sheet	25.9	31.1	30.8	37.6	44.7	42.9	34.8	41.2
Tearing description	W-1	Z-1	W-1	Y-2	W-1	W-1	W-1	Y-1
Splitting description	B-1	C-2	B-1	C-1	C-1	C-3	B-1	B-1
	Sample 3				Sample 4			
Number of sheets torn simultaneously	2	2	7	7	2	2	6	6
Number of tests	5	5	2	2	5	5	3	4
Average instrument reading	19.7	23.0	9.6	11.7	67.6	67.2	29.2	30.0
Average deviation	1.2	1.4	0.2	0.1	2.2	1.4	0.6	1.3
Percentage deviation (individual values)	6.2	5.3	2.3	0.9	3.1	2.1	2.1	2.1
Force in grams to tear single sheet	24.4	28.4	21.9	26.8	83.7	83.2	77.8	80.0
Tearing description	W-1	X-2	W-1	Y-2	W-1	X-1	W-1	Y-2
Splitting description	A-1	B-3	A-1	A-1	C-2	C-3	B-1	C-1
	Sample 5				Sample 6			
Number of sheets torn simultaneously	2	2	4	4	2	2	4	4
Number of tests	5	5	3	3	5	5	4	5
Average instrument reading	98.3	101.6	29.0	30.1	67.2	68.1	16.2	20.1
Average deviation	1.5	1.3	0.5	1.0	2.6	2.8	1.3	0.5
Percentage deviation (individual values)	1.5	1.2	1.7	3.3	3.7	4.1	8.2	2.6
Force in grams to tear single sheet	121.6	125.8	116.0	120.4	83.2	84.3	64.8	80.4
Tearing description	X-1	Z-1	W-1	Z-1	W-1	Z-2	W-1	Z-1
Splitting description	C-2	D-2	C-2	C-1	D-2	D-3	B-1	C-3
	Sample 7				Sample 8			
Number of sheets torn simultaneously	2	2	4	4	1	1	4	4
Number of tests	5	5	5	4	5	5	4	5
Average instrument reading	72.5	86.4	21.2	23.4	74.5	78.1	44.6	47.4
Average deviation	2.7	2.4	0.4	0.6	2.2	2.8	1.8	1.0
Percentage deviation (individual values)	3.7	2.8	2.0	2.6	3.0	3.6	4.1	2.1
Force in grams to tear single sheet	89.8	106.8	84.8	93.6	184.3	193.2	178.4	189.6
Tearing description	W-1	Z-2	W-1	W-2	W-1	Z-1	W-1	Y-2
Splitting description	C-2	D-3	C-3	C-1	F-2	F-2	D-1	D-2
	Sample 9				Sample 10			
Number of sheets torn simultaneously	2	2	8	8	2	2	6	6
Number of tests	5	5	6	7	5	5	2	2
Average instrument reading	13.1	17.7	8.8	10.4	10.5	17.1	6.2	6.8
Average deviation	1.2	0.9	0.1	0.1	1.5	1.4	0.1	0.1
Percentage deviation (individual values)	8.9	5.3	1.7	1.4	14.7	8.1	0.7	1.4
Force in grams to tear single sheet	16.2	21.9	17.6	20.8	13.0	21.2	16.5	18.1
Tearing description	W-1	Z-1	W-1	Y-2	W-2	W-3	W-1	W-3
Splitting description	B-1	C-3	A-1	B-1	C-1	C-1	B-1	B-1
	Sample 11				Sample 12			
Number of sheets torn simultaneously	2	2	7	7	2	2	7	7
Number of tests	5	5	5	5	5	5	5	5
Average instrument reading	14.6	19.2	7.7	10.1	9.5	11.0	4.1	5.5
Average deviation	0.6	2.0	0.3	0.2	1.9	0.7	0.1	0.0
Percentage deviation (individual values)	4.5	10.5	4.0	1.7	20.6	6.6	2.1	0.8
Force in grams to tear single sheet	18.1	23.8	17.6	23.1	11.8	13.6	9.4	12.6
Tearing description	W-1	Z-1	W-1	Y-2	W-1	X-1	W-1	Y-1
Splitting description	B-1	C-3	B-1	B-3	N	B-1	N	B-1
	Sample 13				Sample 14			
Number of sheets torn simultaneously	2	2	10	10	2	2	30	30
Number of tests	5	5	5	5	5	5	3	3
Average instrument reading	3.9	9.6	3.6	3.9	3.2	4.9	6.4	7.0
Average deviation	1.8	0.9	0.3	0.1	1.4	1.9	0.1	0.0
Percentage deviation (individual values)	46.2	9.7	8.8	1.6	43.6	40.0	10.3	0.0
Force in grams to tear single sheet	4.8	11.9	5.8	6.2	4.0	6.1	3.4	3.7
Tearing description	W-1	Z-3	W-1	Y-1	Z-1[a]	X-2[a]	W-1	W-1
Splitting description	B-1	B-1	A-1	A-1	A-1	B-1	N	N
	Sample 15				Sample 16			
Number of sheets torn simultaneously	2	2	30	30	1	1	2	2
Number of tests	5	5	3	3	5	3	5	5
Average instrument reading	2.7	2.2	12.6	12.8	[b]	[b]	18.4	15.6
Average deviation	0.9	0.4	0.2	0.8	...	...	0.9	0.5
Percentage deviation (individual values)	34.3	17.1	5.1	14.5	...	...	4.8	3.2
Force in grams to tear single sheet	3.4	2.7	6.7	6.8	...	...	147.2	124.8
Tearing description	W-1	W-2	W-1	Y-2	...	...	Y-1	Y-2
Splitting description	B-1	B-1	A-1	N	...	...	E-1	E-2

[a] Some difficulty was experienced in making these tears.
[b] Splitting was extremely heavy and carried the tears to the edges of the sheets before the tears had been completed.

Data on the results for the first 16 samples are presented in Table III (Sample 17 was employed in a special test given later). In performing this work, the dial of the Brecht-Imset tester was set near zero and the zero reading was obtained through ten free swings just before and just after testing each sample; the average zero reading was subtracted from the average instrument indication to obtain the "average instrument reading" entered in Table III. The instrument constant found in this study (4.95) was employed, but no attempt was made to correct each reading for the cam error shown graphically in Fig. 4. Every precaution was exercised in the testing with both instruments. All samples were conditioned and tested under standard conditions—73°F. and 50% relative humidity. In the testing of a number of samples with the Brecht-Imset tester, it was observed that the initial tear produced a very nonideal and undesirable condition of flexing in the test specimens, which is difficult to picture or to describe in words. On touching the specimen lightly with the fingers, the paper snaps into the desired condition of flexure shown in the photograph of Fig. 1. This operation is suggested by the manufacturer, because it is believed that, without this corrective preparation of the specimen after the initial tear, the subsequently measured tear would be unsatisfactory.

The designations for the various columns and rows of Table III are self-explanatory, with the possible exception of "average deviation." This is the average deviation of the individual values from the average without regard for algebraic sign. Attention is directed particularly to "tearing description" and "splitting description." The code employed is given below. In each case, the Brecht-Imset reading (computed to a single sheet) is divided by two to yield force in grams (equation (10)).

Explanation of the Tearing and Splitting Designations (Table III):

Nature of tear

W—Straight; tear progressed along a straight line.

X—Fairly straight; tear progressed along an essentially straight line, but with slight irregularities.

Y—Curved; tear progressed along a curved line.

Z—Irregular; tear progressed in no definite manner.

Tearing direction

1—In the idealized direction.

2—Within about 10° of the idealized direction.

3—Marked departure from the idealized direction (between about 10 and 30° away from the idealized direction).

Degree of splitting

N—No apparent splitting.
A—Very slight splitting (Fig. 6, A).
B—Slight splitting (Fig. 6, B).
C—Moderate splitting (Fig. 6, C).
D—Moderate to heavy splitting Fig. 6, D).
E—Heavy splitting (Fig. 6, E).
F—Very heavy splitting (Fig. 6, F).

Splitting behavior

1—Constant; amount of splitting did not vary as tear progressed.

2—Increasing; amount of splitting increased as tear progressed.

3—Irregular; the splitting either varied from point to point in any single tear, or from tear to tear.

Photographs of specimens torn in the Brecht-Imset tester which typify the various degrees of splitting indicated in Table III are presented in Fig. 6. Razor cuts were made in the specimens at the ends of the zones of tear so that the side portions could be partially removed, thereby showing more clearly the torn edges. The distances between the central vertical axes and the marked points in the tears are the lengths of initial tear; the remaining length of each tear is the length (L') over which the instrument measured the tearing strength. A study of the specimens shows that the initial tear does not establish a constant degree of splitting or skinning for the measured portion of the tear, nor does the mode of tearing employed in the Brecht-Imset instrument reduce the degree of splitting below that found in the use of the Elmendorf mode of tearing. Apparently the only advantage of the initial tear, for the given mode of tearing employed in the Brecht-Imset tester, is that it eliminates uncertainty in L' which would be caused by bending of the specimen around the leading edge of the ram and the dependence of this uncertainty on the stiffness of the paper.

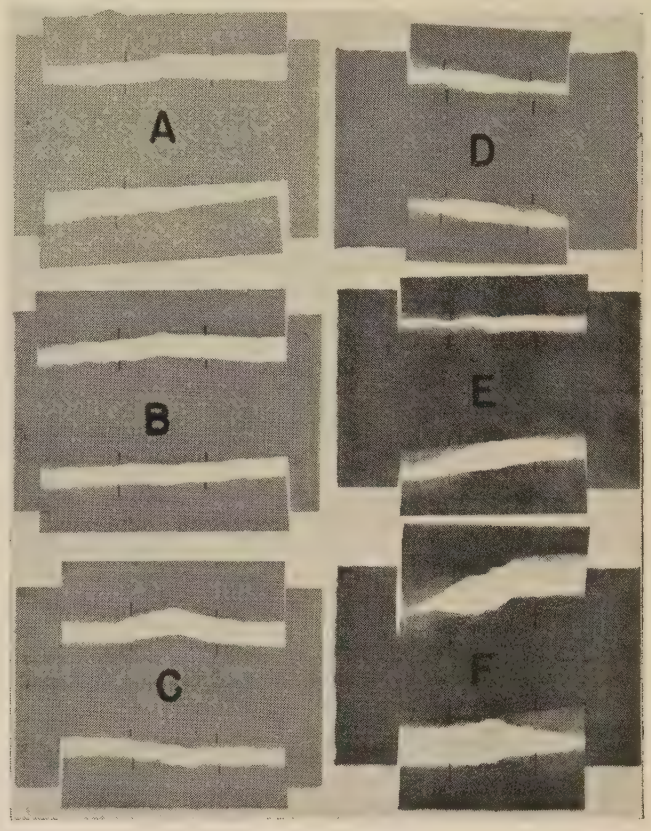

Fig. 6. Photographs of specimens after testing in the Brecht-Imset tester

The specimens are arranged in increasing order of splitting or skinning.

An important defect of the Brecht-Imset mode of tearing was noted in the testing of thin, flexible papers (for example, samples 12–15). Such papers had a

tendency to pull out from the fixed metal fingers and considerable caution had to be exercised to start the tear.

In the testing of heavy papers, tests are often invalidated by the tear running out to the edge of the specimens before the pendulum comes to the end of its first swing (end of the tearing).

The splitting observed in the use of both instruments was strongly dependent on the number of sheets which were simultaneously torn. In general, more specimens are simultaneously torn in the Elmendorf method, which probably accounts for the lesser degree of splitting observed in the use of the Elmendorf-Thwing tester.

In comparing the numerical data obtained with the two instruments, the reader should bear in mind the

Table IV. Dependence of Tearing Strength and the Nature of Tearing on the Number of Sheets Torn Simultaneously

Sample 3a

Number of sheets torn simultaneously	Machine direction 1	2	4	8	16	32	64	Cross-machine direction 1	2	4	8	16	32	64
Brecht-Imset														
Number of tests	10	10	10	5	5	..	..	10	10	10	5	5	..	..
Average instrument reading	4.2	10.5	22.4	45.9	90.2	..	..	4.6	12.0	25.8	52.7	104.1	..	..
Average deviation	0.9	1.1	1.2	0.6	3.2	..	..	0.7	1.0	1.5	0.8	2.3	..	..
Percentage deviation (individual values)	21.4	10.8	5.4	1.4	3.6	..	..	16.4	8.1	5.7	1.5	2.2	..	..
Force in grams to tear single sheet	10.4	13.0	13.9	14.2	13.9	..	..	11.4	14.8	16.0	16.3	16.1	..	..
Tearing description	W-1	X-1	W-1	W-1	W-1	..	..	Z-2	Z-2	X-2	X-2	X-2	..	..
Splitting description	B-3	B-3	B-3	A-1	A-1	..	..	C-3	C-3	C-3	B-3	A-3	..	..
Elmendorf														
Number of tests	10	10	10	5	5	5	4	10	10	10	5	5	5	3
Average instrument reading	0.9	2.0	3.6	7.1	14.0	30.0	68.0	1.0	1.9	3.9	7.9	15.0	32.0	74.4
Average deviation	0.0	0.1	0.1	0.1	0.1	0.4	1.2	0.0	0.1	0.1	0.1	0.1	0.4	1.2
Percentage deviation (individual values)	3.5	3.7	3.5	2.1	0.7	1.3	1.8	5.1	3.2	3.2	0.7	0.7	1.2	1.6
Force in grams to tear single sheet	14.4	16.0	14.4	14.2	14.0	15.0	17.0	16.0	15.2	15.6	15.8	15.0	16.0	18.6
Tearing description	W-1	W-1	W-1	W-1	W-1	W-1	Y-2	Y-1	Y-1	Y-2	Y-2	Y-2	Y-2	Y2
Splitting description	B-3	B-3	A-3	A-3	A-1	A-1	A-1	B-1	B-1	B-1	A-1	A-1	N	N

Sample 5A

Number of sheets torn simultaneously	Machine direction 1	2	3	6	9	Cross-machine direction 1	2	3	6	9
Brecht-Imset										
Number of tests	10	8	5	...	...	10	8	5	...	...
Average instrument reading	57.6	96.1	136.5	...	...	62.5	96.5	137.2	...	...
Average deviation	2.4	3.0	0.5	...	...	2.8	2.0	0.5	...	...
Percentage deviation (individual values)	4.2	3.1	0.4	...	...	4.5	2.1	0.4	...	...
Force in grams to tear single sheet	143	119	113	...	...	155	119	113	...	...
Tearing description	W-2	W-2	W-1	...	...	X-2	X-2	X-1	...	...
Splitting description	E-2	D-2	C-2	...	...	F-2	D-2	C-2	...	...
Elmendorf										
Number of tests	10	10	5	5	5	10	10	5	5	5
Average instrument reading	8.3	16.1	23.8	46.7	70.6	7.1	14.1	21.8	44.6	68.8
Average deviation	1.0	0.9	1.2	1.0	1.1	0.2	0.4	0.9	1.0	0.8
Percentage deviation (individual values)	11.8	5.6	5.2	2.2	1.5	2.7	3.1	4.2	2.4	1.2
Force in grams to tear single sheet	132.8	128.8	127.0	124.7	125.5	113.7	112.8	116.2	119.0	122.4
Tearing description	W-2	W-2	W-1	X-2	W-2	X-1	X-2	W-1	X-2	X-1
Splitting description	F-2	E-2	E-2	C-3	C-3	D-3	D-3	C-1	C-1	C-1

Sample 17

Number of sheets torn simultaneously	Machine direction 1	2	4	8	16	32	Cross-machine direction 1	2	4	8	16	32
Brecht-Imset												
Number of tests	10	10	5	5	..	..	10	10	5	5	..	..
Average instrument reading	13.6	31.7	63.6	120.8	..	..	15.7	35.6	70.8	133.5	..	..
Average deviation	1.5	1.8	1.0	3.2	..	..	2.6	2.3	2.3	1.9	..	..
Percentage deviation (individual values)	11.2	5.5	1.5	2.7	..	..	16.4	6.4	3.2	1.5	..	..
Force in grams to tear single sheet	33.7	39.2	39.4	37.4	..	..	38.9	44.1	43.8	41.3	..	..
Tearing description	W-2	W-2	W-2	W-2	.	..	Z-2	Z-2	Z-2	X-2	..	..
Splitting description	D-3	D-3	C-1	B-1	..	..	D-3	D-3	C-3	B-1	..	..
Elmendorf												
Number of tests	9	10	4	5	5	5	10	10	5	5	5	4
Average instrument reading	2.0	4.5	8.5	18.5	38.6	84.6	2.2	4.9	9.6	20.2	42.0	100.7
Average deviation	0.0	0.3	0.2	0.5	1.1	2.0	0.0	0.1	0.1	0.3	0.2	1.4
Percentage deviation (individual values)	0.0	6.4	2.0	3.0	2.9	1.7	2.3	2.8	1.6	1.2	0.5	1.4
Force in grams to tear single sheet	32.0	36.0	34.0	37.0	38.6	42.3	35.2	39.2	38.4	40.4	42.0	50.3
Tearing description	W-1	W-1	W-1	W-1	W-1	W-1	Y-1	Y-2	X-1	X-1	X-2	Y-2
Splitting description	C-1	C-3	C-3	B-1	B-1	A-1	D-3	D-1	B-3	B-1	B-1	B-1

fact that different numbers of sheets were simultaneously torn. The average tearing force in grams per sheet is shown graphically in Fig. 7. It will be seen that, generally, the tearing strengths obtained with the two instruments are of the same order of magnitude. The tendency of the numerical result obtained with the Brecht-Imset tester to be higher than the corresponding result obtained with the Elmendorf-Thwing tester is probably attributable to the greater degree of splitting

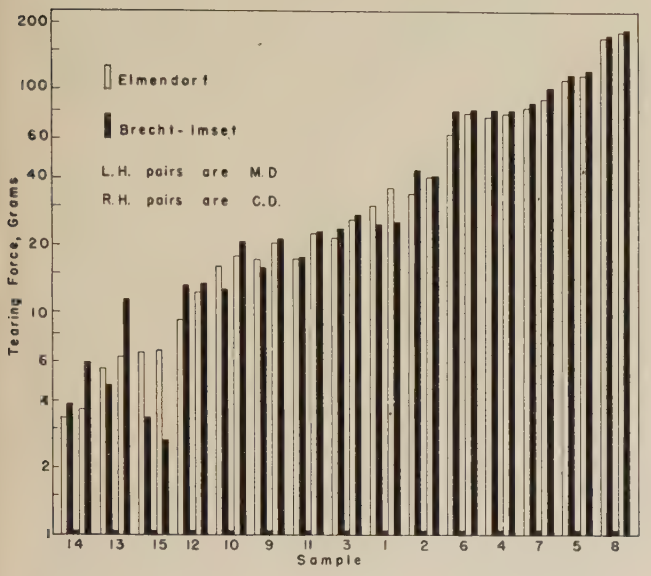

Fig. 7. Comparison of the Brecht-Imset and Elmendorf-Thwing tearing strength testers for a series of 15 different papers. (M.D. = machine direction; C.D. = cross-machine direction)

involved in testing with the former instrument. In the case of a very thin paper (for example, sample 15), where a large number of sheets are simultaneously torn in the Elmendorf-Thwing instrument, it seems likely that the higher result obtained with the Elmendorf method is to be attributed to frictional contact between the torn edges. On the other hand, as previously pointed out, the tearing of lightweight paper in the Brecht-Imset tester is highly nonideal and is accomplished only with difficulty.

With but few exceptions, the observed percentage deviations for individual determinations were substantially smaller in the work done with the Elmendorf method.

The dependence of the computed tearing force per sheet and of the nature of tearing on the number of sheets simultaneously torn was investigated with samples 3a, 5a, and 17. The results are presented in Table IV, and the tearing force per sheet is plotted against the number of specimens simultaneously torn in Fig. 8. In using each instrument, the largest number of sheets torn simultaneously was the maximum which could be read on the instrument for the series, in which the number of sheets was 1, 4, 8, etc.

It will be noted that no general statement can be made regarding the trend of tearing strength with increasing number of sheets simultaneously torn. The results obtained suggest that the apparent tearing strength tends to become constant when the number of sheets simultaneously torn is about two or more and, as might be expected, the two instruments are in better agreement when the same number of sheets are simultaneously torn, and when the number is two or more. The rise in the curve observed with the Elmendorf-Thwing tester at large numbers of specimens simultaneously torn (beyond the capacity of the Brecht-Imset tester) is possibly attributable to frictional binding between the torn edges of the specimens.

CONCLUSIONS

Although designed in close conformity with the mechanical theory for the Brecht-Imset method, the Brecht-Imset through-tear tester is a relatively complex device. In contrast, the Elmendorf-Thwing instrument is among the simplest of all mechanical paper testing devices. Among the consequences of its complexity, the Brecht-Imset tester has high internal friction, which is variable and, therefore, introduces variability in the test results. There is evidence that certain critical parts will rust or corrode and thereby cause error and variability in the data obtained with this instrument. The influence of friction in the Elmendorf-Thwing instrument is known from past studies and general experience to be almost negligible.

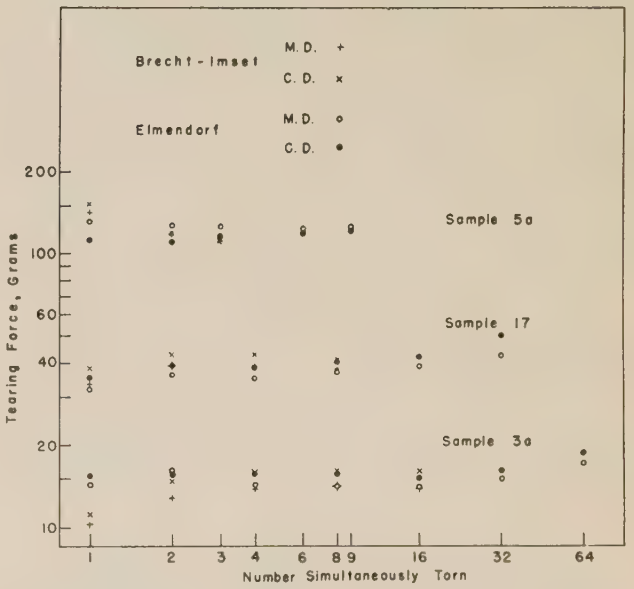

Fig. 8. Influence of the number of specimens simultaneously torn on the tearing strength, calculated to a single sheet

The Brecht-Imset mode of tearing produces four zones of tear in each test, but a smaller number of specimens must be tested simultaneously, which offsets the tendency of the former factor to reduce the variability in test results. The present work is in agreement with past studies carried out elsewhere that it is advantageous, in using the Elmendorf method, to employ a multiplicity of specimens in a single test. The variability observed in the present work with the Elmendorf-Thwing instrument is substantially less than that noted in the data obtained with the Brecht-Imset tester.

The mode of tearing adopted by Brecht and Imset does not lessen, or render more uniform, the degree of splitting or skinning of the paper during the test. Somewhat less splitting was observed in the use of the Elmendorf method. The Brecht-Imset mode of tearing has certain distinctly unfortunate characteristics: many papers cannot be properly torn because the specimen tends to pull away from the fixed metal fingers, and excessive attention must be exercised by the operator to obtain a test result at all; in the testing of almost any kind of paper, the operator must adjust the condition of flexure of the paper after the initial tear and prior to the measured tear; in the testing of certain papers (particularly heavier papers), one of the four tears may run off to the edge of the specimen before the pendulum stops its measuring swing. Similar behavior is sometimes noted in the use of the Elmendorf-Thwing instrument in the testing of certain papers, but the occurrence is not nearly so frequent.

Apart from instrumental variability and the other factors discussed in this report, it is impossible to express an opinion on the accuracy of the Brecht-Imset method as compared with that of the Elmendorf method. Such an opinion must rest on a scientific definition of "tearing strength," which is not at hand. It would appear that the flexing and stressing of a specimen in the immediate zone of tear is similar in the two instruments, so that they should evaluate the same kind of tearing strength and should agree with each other numerically when allowance is made for the perturbing influence of splitting. Thus, it seems logical for one to compare the two instruments on the basis of such factors as instrumental variability, constancy of calibration, limitations on the kinds of papers which may be tested, quality and constancy of quality of the tear produced, and so on. On this basis, the Brecht-Imset method for measuring the through-tear resistance of paper appears to have no advantages over the Elmendorf method.

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2. Brecht, W., and Imset, O., *Wochbl. Papierfabr.* 64, no. 48: 848–853 (Dec. 2, 1933).

This report is one of a series issued as a part of the Instrumentation Program of the American Paper and Pulp Association. The data in this paper were reported to the Association as Report 35, Part II, dated Feb. 1, 1948.

LETTERS TO THE EDITOR

First 9-point from 100% Coniferous Woods

To the Editor of *Tappi:*

On page 57A of the August issue of *Tappi,* in the item regarding the new mill of the San Joaquin Division of Fibreboard Products, Inc., is a misstatement of fact. I refer to the claim that this is "the first plant to make nine-point corrugating material out of 100% coniferous pulpwood."

Thirty years ago when cereal straw was the accepted material for nine-point corrugating, some of it was made from sulphite screenings (from coniferous wood) colored to imitate straw. A number of kraft mills in the South have made an acceptable nine-point corrugating medium from their regular (coniferous) kraft furnish for many years. In 1930, at Bogalusa, La., I helped to develop a semikraft pulp from saw mill waste (longleaf pine) from which a superior quality corrugating medium was made.

Robert H. Stevens, *Technical Director*
National Container Corp., Jackonsville, Fla.

Statistical Quality Control

The following letter was written to a member of TAPPI who inquired for information as to the possibilities of using quality control statistical methods in connection with the manufacture of specialty paper and film materials. Since many companies and individuals are interested in the use of these new quality control techniques and do not know how to apply the methods Mr. Pascoe's response is published as follows:

"Mr. R. G. Macdonald, Secretary of TAPPI, has passed on to me your letter inquiring about the possibility of using statistical quality control methods in connection with the manufacture of specialty paper and film materials. Since I am Chairman of the TAPPI Committee dealing with this subject, he has asked me to reply directly to you.

"The paper and pulp manufacturing and paper converting industries are generally much behind certain other industries in the acceptance and application of statistical quality control methods. One of the reasons for this lack of progress has, undoubtedly, been that the classical methods as first outlined by Shewhart and developed and accepted widely in the metals and electrical parts industries, have to be modified to take into account some of the peculiarities of our allied industries. I am glad to be able to report, however, that there is a slow but healthy growth of the realization of the value of these methods and their usefulness in the general pulp and paper field. As I view this situation there is no question but that there is a real place for the use of statistical quality control methods in the paper and pulp manufacturing and converting field.

"I have pondered a good deal as to how I might pass on to you the most information on this subject in a letter. Without knowing your background in the understanding of the basic statistical concepts I wondered how far back into the beginning of this field I should go. I have finally concluded that perhaps the best way to open the subject is to suggest certain literature that might help you to orient yourself and decide further in which direction you might like to go.

"In accordance with the above I would very strongly recommend for easy reading in the basic principles of statistical quality control the book by Eugene L. Grant entitled, 'Statistical Quality Control' published by the McGraw-Hill Book Company, 1946. This is an excellent book for home study with the only drawback that most of the examples cited and those worked out in detail are slanted toward the metal working industries or the electrical parts industries. Then for some information on the direct application to various phases of paper manufacture and converting I am enclosing a bibliography of papers that I hope will be available to you if you have not already seen them. (Ed. Note: These references are contained in the Bibliography of Pulp and Paper Making by C. J. West, issued annually to TAPPI members.)

"If after you have looked over some of this material there are further more specific problems or questions that you feel we might help you with we would be very glad to have you bring them to our attention. Our TAPPI Committee is composed of members who have varied background in this field and usually, therefore, some kind of answer can be obtained from some of the members regarding specific problems.

"Trusting that this information may assist you to get started along this road, I remain

T. A. Pascoe, *Chairman*
Committee on Statistical Methods"

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Calendar of TAPPI Meetings

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Annual Meeting, Commodore Hotel, New York, N. Y., February 19–22, 1951.

Second Coating Conference, Statler Hotel, Boston, Mass., April 18–20, 1951
- General Chairman—J. H. Heuer, St. Regis Paper Co., Deferiet, N. Y.
- Program Chairman—Alfred D. Bonanno, Champion-International Co., Lawrence, Mass.

Sixth Engineering Conference of the Pulp and Paper Industry, General Oglethorpe Hotel, Wilmington Island, Savannah, Ga., October 15–18, 1951
- General Chairman—George H. Pringle, Mead Corp., Chillicothe, Ohio.
- Local Arrangements Chairman—James R. Lientz, Union Bag & Paper Co., Savannah, Ga.

LOCAL SECTIONS

Ohio Section:
- December 12, 1950, Manchester Hotel, Middletown, Ohio.
- January 9, 1951, Manchester Hotel, Middletown, Ohio.
- February 8, 1951, Manchester Hotel, Middletown, Ohio.
- March 8, 1951, Manchester Hotel, Middletown, Ohio.

Pacific Section:
- February 6, 1951, Olympia, Wash.
- April 13, 1951, Longview, Wash.

New England Section:
- November 17, 1950, Roger Smith Hotel, Holyoke, Mass.
- January 19, 1951, Roger Smith Hotel, Holyoke, Mass.

Lake Erie Papermakers and Converters:
- November 17, 1950, Hickory Grill, Cleveland, Ohio.
- December 15, 1950, Hickory Grill, Cleveland, Ohio.
- January 19, 1951, Hickory Grill, Cleveland, Ohio.
- February 16, 1951, Hickory Grill, Cleveland, Ohio.

Delaware Valley Section:
- November 30, 1950, Engineers Club, Philadelphia, Pa.
- January 25, 1951, Engineers Club, Philadelphia, Pa.
- March 22, 1951, Engineers Club, Philadelphia, Pa.

Chicago Section:
- November 20, 1950, Chicago Bar Association, Chicago, Ill.
- December 18, 1950, Chicago Bar Association, Chicago, Ill.
- January 15, 1951, Chicago Bar Association, Chicago, Ill.

Metropolitan Group, Empire State Section:
- January 9, 1951, Fraunces Tavern, New York, N. Y.
- March 6, 1951, Fraunces Tavern, New York, N. Y.

Lake States Section:
- January 9, 1951, American Legion Clubhouse, Appleton, Wis.
- March 13, 1951, Stevens Point, Wis.

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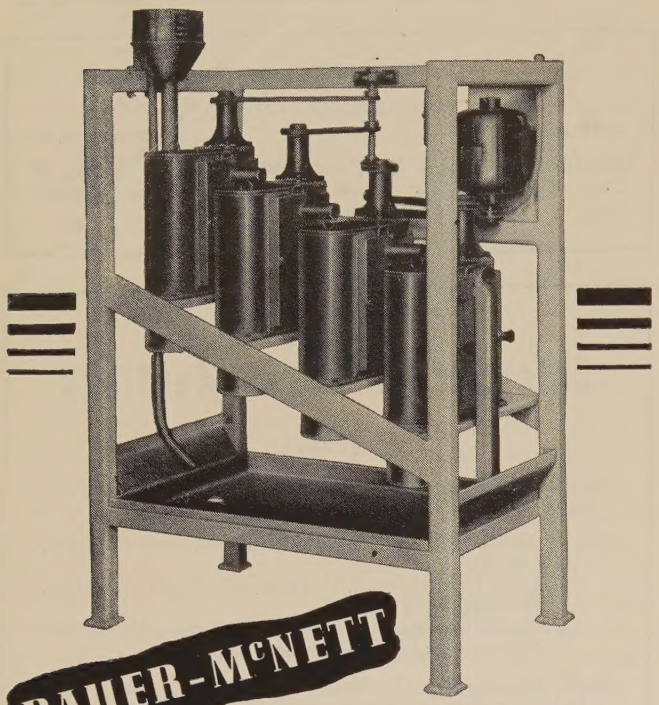

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